

# THE MATERIALS RESEARCH LABORATORY

THE PENNSYLVANIA STATE UNIVERSITY

## FIRST SEMIANNUAL REPORT

ON

Research on The Mechanism and Kinetics of

Oxidation of Silicon in Air

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For the period

1 June 1965 to 30 November 1965

Grant Number NASA Grant NGR-39-009-042

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UNIVERSITY PARK, PENNSYLVANIA

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## SUMMARY

This first semiannual report describes the initial work on a project concerned ultimately with the understanding of the mechanism and kinetics of oxidation of silicon. The ellipsometer and its various optical, mechanical and electronic accessories have been assembled and tested. The exact equation of ellipsometry has been programmed for the IBM 7074 computer and the values of  $\psi$  and  $\Delta$  for various values of the thickness and refractive index of the film on silicon substrate have been evaluated.

The ultrahigh vacuum system as well as the "buffer" system at moderate vacuum have also been assembled and tested and are now ready for operation.

## I. INTRODUCTION

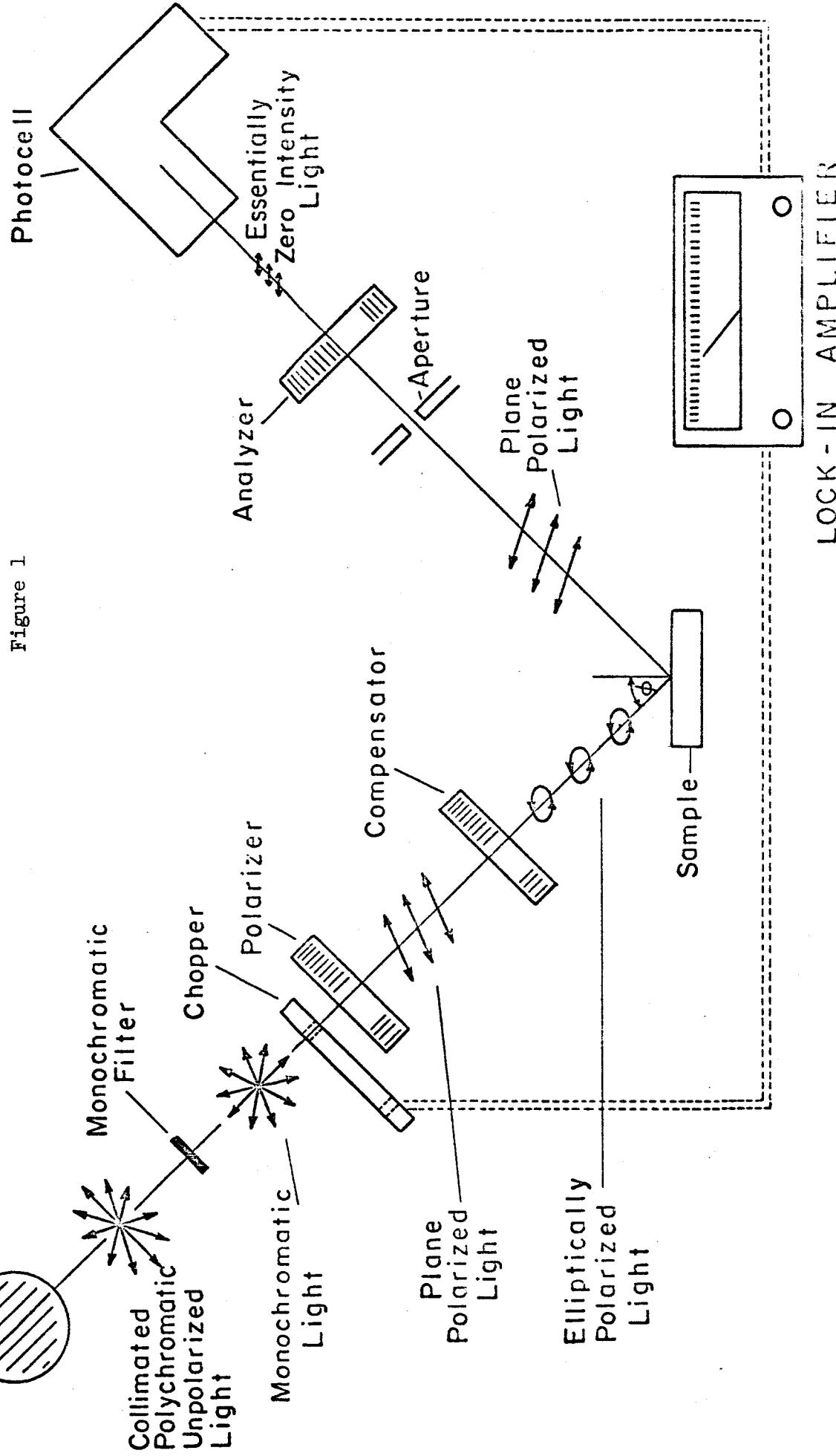
Even though numerous papers have appeared on the various ways and means of diminishing or even to some extent controlling the surface contamination effects by the ambient atmosphere, very little work has been carried out on the actual mechanism and kinetics of the contamination of the surface of silicon in air. The present project is intended to provide this information by making use of two techniques namely (i) the ellipsometer technique of determining the refractive index and the thickness of the layer on the silicon surface and (ii) the oxygen-buffer technique of controlling the oxygen partial pressure at extremely low levels. Both these techniques are described below in greater detail. Much of the effort during this report period has been devoted to the design, fabrication and ordering, assembling and testing of the various equipments.

## II. ELLIPSOMETRY

2.1 Experimental technique: Since this has become a well recognized tool for the study of the surfaces and their contamination and consequently a large amount of literature<sup>(1)</sup> on this technique is available, only a brief mention will be made about the experimental set up. A schematic and self-explanatory drawing of the experimental arrangement is shown in Fig. 1. Instead of the conventional photometer detecting systems, a chopper-cum lock-in-amplifier system has been incorporated to increase the signal to noise ratio considerably. The lock-in-amplifier operates as extremely narrow band detector, the center frequency of which is locked to the frequency of the chopper kept in the incident beam. With this arrangement it is now possible to measure rapidly the angles  $\Delta$  and  $\Psi$  to  $0.01^\circ$  with excellent reproducibility.

## Light & Collimating Lenses

Figure 1



The ellipsometer and the lock-in-amplifier are from Gaertner Scientific Instruments Co. and Princeton Applied Research respectively.

Currently all the measurements are confined to the Hg  $\lambda$  5461 Å only.

2.2 Interpretation of ellipsometer measurements: The effect of very thin films on ellipsometric measurements requires some discussion. Although the theoretical foundation necessary to calculate the effect of thin films on the state of polarization of reflected light was laid over 70 years ago by Drude<sup>(2)</sup>, the exact equations cannot be solved in closed form for the desired quantities (refractive index and thickness of film) in terms of the measured quantities  $\Delta$  and  $\Psi$ , the angles which define the ratio of the Fresnel coefficients for light wave components parallel (p) and perpendicular (s)

$$\frac{R_p}{R_s} = \tan \Psi \exp(i\Delta) \quad (1)$$

Hence trial-and-error and iteration techniques must be used and before the advent of the modern computers the application of the exact equation was almost impossible.

Consequently, approximate expressions have been used extensively, but the limits of their validity are not known. Thus the results obtained by the earlier workers and hence the conclusions are often of doubtful nature<sup>(3,4)</sup>.

However, with the modern electronic computers the use of exact equations is routine, once the initial programming is complete. Such a program has been written for the IBM 7074 in the DAFT (Dual Autocoder Fortran Translator) language and is included in Appendix I. Daft language is an improved version of the Fortran and is used in Pennsylvania State University. Daft can easily be translated to Fortran. The values of  $\Delta$  and  $\Psi$  as a function of

film thickness obtained with this program for various values of the refractive index of the film ( $n_1 = 1.0 - 50$ ) on a substrate of silicon ( $n_2 = 4.050 - 0.028 i$ ) at  $70^\circ$  angle of incidence for  $\lambda 5461\text{\AA}$  are given in Appendix II. The table also includes the data for films of the phases viterous silica ( $n_1 = 1.460$ ) and  $\beta$ -cristobalite ( $n_1 = 1.487$ ).

In the above treatment the film has been considered to be a three-dimensional phase characterized by a thickness and index of refraction. For monolayers it is rather farfetched to expect the quantity  $n_1$  to be the same as the index of refraction of the film material in the bulk phase. For films with partial monolayer coverage the problem is even more complicated.

On the other hand, Strachan<sup>(5)</sup> and Sivukhin<sup>(6)</sup> has derived the Fresnel coefficients treating the two-dimensional monolayer model of the film, as a surface distribution of Hertzian oscillators. To the first-order approximation Strachan's theory leads to the following equation<sup>(7)</sup> for the ratio of the Fresnel's coefficients:<sup>\*</sup>

$$\tan \psi \exp(i\Delta) = \tan \bar{\Psi} \exp(i\bar{\Delta}) \left\{ 1 - \frac{i.4\pi \cos \phi \sin^2 \phi}{\lambda (1 - \frac{1}{n_2^2})(\cos^2 \phi - \frac{\sin^2 \phi}{n_2^2})} \right. \\ \left. \times \left[ 2\sigma_1 \left( \frac{1}{n_2^4} - \frac{\csc^2 \phi}{n_2^2} \right) + 2\sigma_2 \left( \frac{\cot^2 \phi}{n_2^2} - \frac{1}{n_2^4} \right) + 2\sigma_3 \right] \right\} \quad (2)$$

This equation reduces to

$$\Delta = \bar{\Delta} - \theta \sum_i \alpha'_i \sigma'_i \quad (3)$$

$$\psi = \bar{\Psi} + \theta \sum_i \beta'_i \sigma'_i \quad (4)$$

For purposes of comparison the corresponding equations derived on the basis of Drude's theory are given below:

\* See Table I for Glossary of Symbols.

Table I. Glossary of Symbols

$a$	$(1-k^2)/n^2(1+k^2)^2$
$a_1$	$2k/n^2(1+k^2)^2$
$d$	thickness of film
$n_1$	index of refraction of film
$\bar{n}_2$	index of refraction of substrate = $n_2 - ik_2$ = $n_2(1-i k)$
$\Delta$	$\Delta$ for a film-free surface
$\bar{\psi}$	$\psi$ for a film-free surface
$\lambda$	vacuum wavelength of light
$\phi$	angle of incidence
$\sigma_i = \theta \sigma_i'$	scattering indices
$\theta$	degree of coverage
$\phi = \frac{360}{\lambda} d(n_1^2 - \sin^2 \phi)^{1/2}$	

$$\tan \psi \exp(i\Delta) = \tan \bar{\psi} \exp(i\bar{\Delta}) \left\{ 1 - \frac{i 4\pi \cos \phi \sin^2 \phi}{\lambda \left(1 - \frac{1}{n_2^2}\right) \left(\cos \phi - \frac{\sin^2 \phi}{n_2^2}\right)} x \right. \\ \left. \left( \frac{1}{n_1^2} - \frac{1}{n_2^2} \right) (n_1^2 - 1)d \right\} \quad (5)$$

and

$$\Delta = \bar{\Delta} - \alpha d \quad (6)$$

$$\psi = \bar{\psi} + \beta d \quad (7)$$

where

$$\alpha = \frac{4\pi \cos \phi \sin^2 \phi (n_1^2 - 1) \left\{ \left( \frac{1}{n_1^2} - a \right) \left[ \cos^2 \phi - a + \sin^2 \phi (a^2 - a_1^2) \right] + a_1^2 (1 - 2a \sin^2 \phi) \right\}}{\lambda \left\{ [\cos^2 \phi - a + \sin^2 \phi (a^2 - a_1^2)]^2 + a_1^2 (1 - 2a \sin^2 \phi)^2 \right\}}$$

$$\beta = \frac{2\pi \sin 2\bar{\psi} \cos \phi \sin^2 \phi (n_1^2 - 1) a_1 \left\{ \left( \frac{1}{n_1^2} - a \right) \cdot (1 - 2a \sin^2 \phi) - [\cos^2 \phi - a + \sin^2 \phi (a^2 - a_1^2)] \right\}}{\lambda \left\{ [\cos^2 \phi - a + \sin^2 \phi (a^2 - a_1^2)]^2 + a_1^2 (1 - 2a \sin^2 \phi)^2 \right\}}$$

It is seen that equations (2) and (5) are identical except for the quantities in brackets which contain terms that characterize the film, i.e., scattering indices in one case and thickness and refractive index in the other case.

Recently Saxena<sup>(4)</sup> has shown that the error involved in using the linear approximation equation (6) for deriving the film thickness  $d$  is within  $1 \text{ \AA}$  up to  $d = 50 \text{ \AA}$  and within  $6 \text{ \AA}$  up to  $d = 100 \text{ \AA}$ . On the other hand, the equation (7) leads to an error of as much as  $75 \text{ \AA}$  in a true film thickness of  $100 \text{ \AA}$ .

Archer has pointed that the value of  $\beta$  in equation (7) is very small ( $\sim 0.001 \text{ deg/\AA}$ ). One would, therefore, expect a large contribution from the second and higher order terms and, hence, a departure from linear behavior even at small film thickness.

In the light of the above facts, it is necessary to examine the validity of the linear approximation in the case of equations (3) and (4) derived from Strachan's theory. The validity of the linear approximation

can also be experimentally tested by using different ambient atmospheres (hydrogen, nitrogen, etc.) to form different adsorbed films on atomically clean surfaces of silicon.

### III. Oxygen-Buffer Technique

Fig. 2 represents the phase diagram of the  $\text{FeO}-\text{Fe}_2\text{O}_3$  system (Muan<sup>(8)</sup>).

Here the temperature in °C is plotted along the ordinate and the weight percent along the abscissa. The dashed lines represent the isobars for the partial pressure of oxygen. From the right-hand part of the diagram it can be seen that a mixture of  $\text{Fe}_3\text{O}_4$  and  $\text{Fe}_2\text{O}_3$  of any composition by weight whatever will maintain a constant oxygen partial pressure depending only on the temperature. If such a system is incorporated in a vacuum system one could control the partial pressure of oxygen in the system. Further if there is a leak in the system oxygen will be absorbed by the  $\text{Fe}_3\text{O}_4-\text{Fe}_2\text{O}_3$  mixture, and if there is a depletion of oxygen in the system for any reason whatever, the mixture will release oxygen. In this way the partial pressure of oxygen in the system can be maintained at a constant value.

Such an oxygen-buffer system has been designed, fabricated, assembled and tested. This buffer system is coupled on to a conventional high vacuum system reaching down to  $10^{-8}$  mm Hg pressure. In addition we have also acquired an ultrahigh vacuum system using a 15 l/sec Vac-Ion pump yielding an ultimate vacuum of  $1 \times 10^{-9}$  mm Hg.

For cleaving the silicon crystal in vacuum to produce an atomically clean surface, an apparatus has been designed on the lines of Gobeli and Allen<sup>(9)</sup> apparatus. This requires some stainless steel sylphon bellows for

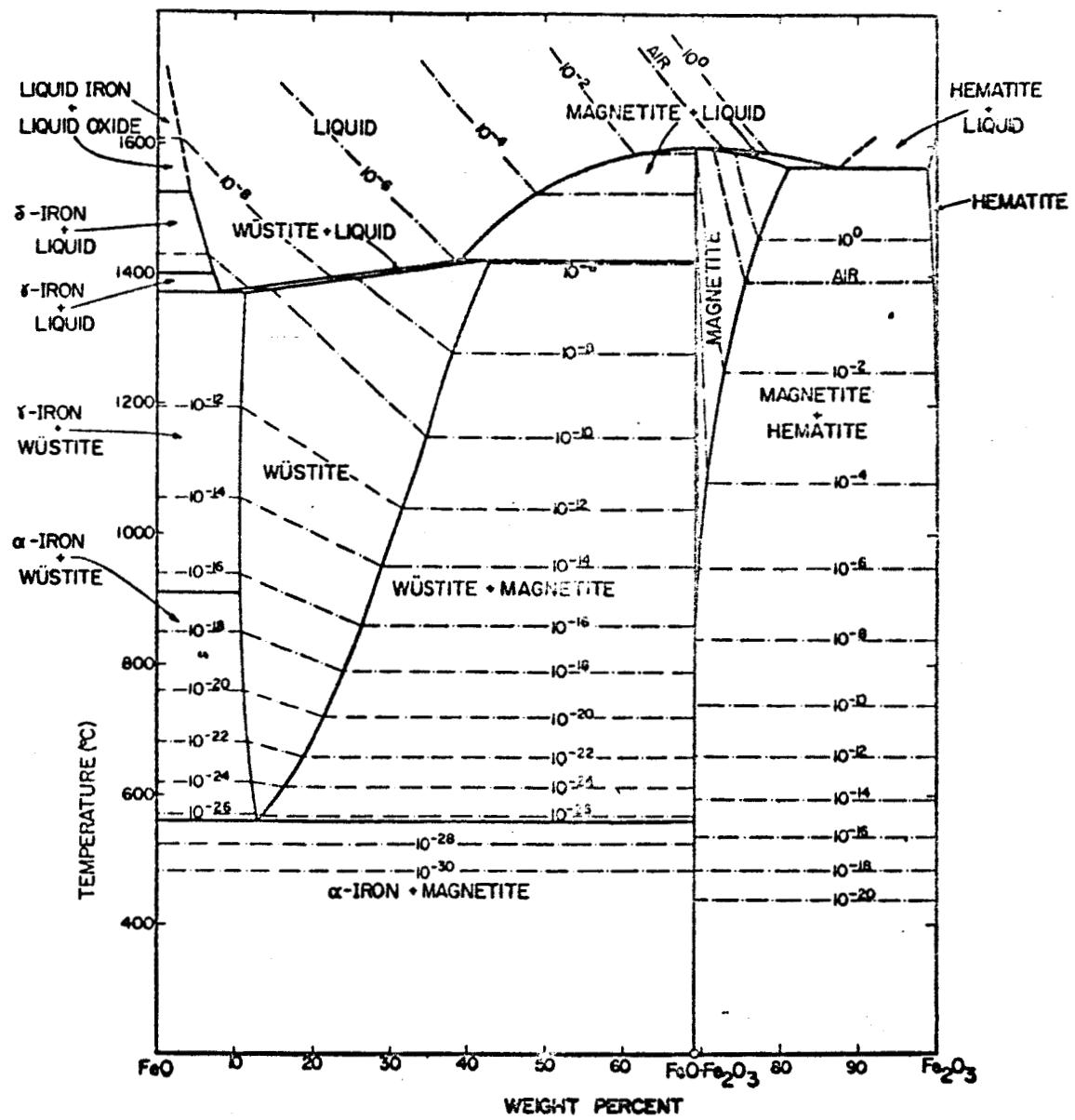


Fig. 2. Phase Equilibrium Diagram of the System  $\text{FeO}-\text{Fe}_2\text{O}_3$

which orders were placed in August '65. Due to some unforeseen strike in the manufacturing firm we are yet to receive the sylphon bellows. However, we expect to receive the bellows shortly and as soon as they are received and the cleaving apparatus is ready the experimental investigations will be commenced.

#### IV. References

1. "Ellipsometry in the Measurement of Surfaces and Thin Films", Ed. E. Passaglia, R. R. Stromberg and J. Kruger, Nat. Bur. Stds. Misc. Pub. No. 256, 1964.
2. P. Drude, Wied. Ann. Phys. 36, 884 (1889).
3. D. K. Burge and H. E. Bennett, Jour. Opt. Soc. Amer. 54, 1428 (1964).
4. A. N. Saxena, ibid 55, 1061 (1965).
5. C. S. Strachan, Proc. Camb. Phil. Soc. 29, 116 (1933).
6. D. V. Sivukhin, Sov. Phys. - JETP 3, 269 (1956).
7. R. J. Archer and G. W. Gobeli, Jour. Phys. Chem. Solids 26, 343 (1965).
8. A. Muan, Amer. Jour. Sci. 256, 171 (1958).
9. G. W. Gobeli and F. G. Allen, Jour. Phys. Chem. Solids 14, 23 (1960).

#### V. Conclusions and Recommendations

No specific conclusions can be drawn at this stage of the work. It is recommended that the work be allowed to proceed as outlined above.

#### VI. Personnel

Besides the Principal Investigator\* the following persons are working on this project:

Dr. V. Prosser, Senior Research Associate, 1/4 time since September 1, 1965

Mr. R. Rai, Graduate Assistant, 3/4 time July-September, 1965  
1/2 time since September, 1965

\* K. Vedam, Associate Professor of Solid State Science

## APPENDIX I

A DAFT Program for the Interpretation of Ellipsometer  
Measurements

```

BEGIN MULTIPLE DECK COMPILE
BEGIN DAFT SOURCE DECK
      RAD(A)=A*3.1415927/180.
      DEG(A)=(A*180.)/3.1415927
      DIMFNSION RNX(30),DEL(2,91),DELTA(2,91),PSI(2,91)
      PRINT TITLE
      TITLE FORMAT(1,P1,T5, 'TABULATION OF DELTA AND PSI USING EXACT EQUATION
      2FOR DIFFERENT REFRACTIVE INDICES AND FILM THICKNESS OF!
      3 T50,'SILICON-SILICON OXIDE SYSTEM' )
C FOLLOWING PROGRAM CAN BE USED TO FIND DELTA AND PSI FOR ANY SYSTEM IN WHICH
C EXACT EQUATION IS USED.
C PROGRAM WRITTEN IN DAFT
C N=NUMBEROF INDICES OF REFRACTION OF SILICON OXIDE TO BE READ IN.
      RFAD 100 ,N,A,RNX2,RK2
C REFRACTIVE INDEX OF SILICON= RNX2-I*(RK2)
C REFRACTIVE INDEX OF SILICON OXIDE =RNX1
      100  FORMAT(T7,I4,T15,F6.2,T25,F6.3,T35,F4.3)
      A=RAD(A)
      SINA=SIN(A)
      COSA=COS(A)
      ALPHA1=(RNX2**2)-(RK2**2)-(SINA**2)
      ALPHA2=2.*RNX2*RK2
      RNO=SQRT(ALPHA1**2+ALPHA2**2)
      APHI=-ATAN(ALPHA2/ALPHA1)
      R1NO=SQRT(RNX2**2+RK2**2)
      APHI1=-ATAN(RK2/RNX2)
      R2NO=SQRT(RNO)/R1NO
      APHI2=APHI/2.0 - APHI1
      ALPHA3=R2NO*COS(APHI2)
      ALPHA4=R2NO*SIN(APHI2)
      DEL(1,1)=0.
      DEL(2,1)=0.
      DO 200 J=1,90
      DFL(1,J+1)=DEL(1,J)+2.
      200  DEL(2,J+1)=RAD(2.0*DFL(1,J+1))
      RFAD 101, (RNX(J),J=1,N)
      101  FORMAT(8F10.3)
      DO 1000 I=1,N
      RNX1=RNX(I)
      COSB=COS(ASIN(SIN(A)/RNX1))
      RD=RNX1*ALPHA3-RNX2*COSB
      RF=RNX1*ALPHA4+RK2*COSB
      PF=RNX1*ALPHA3+RNX2*COSB
      RG=RNX1*ALPHA4-RK2*COSB
      RI=RNX1*COSB-RNX2*ALPHA3-RK2*ALPHA4
      RJ=RK2*ALPHA3-RNX2*ALPHA4
      RK=RNX1*COSB+RNX2*ALPHA3+RK2*ALPHA4
      RN=PNX2*ALPHA4-RK2*ALPHA3
      CALL POLMQP(PD,RF,RF,RG,COSB,COSA,RL,RO,RP,RNX1)
      CALL POLMQR(RI,RJ,RK,RN,COSB,COSA,RM,RQ,RR,RNX1)
      DO 300 J=1,91
      CS2D=COS(DFL(2,J))
      SN2D=SIN(DFL(2,J))
      CALL STUVWX(RL,RO,RP,CS2D,SN2D,W,X)
      CALL STUVWX(RM,RQ,RR,CS2D,SN2D,W1,X1)
      DENR=W1**2+X1**2
      Y=(W*W1+X*X1)/DENR
      Z=(X*W1-W*X1)/DENR
      DELTA(1,J)=ATAN(Z/Y)
      PSI(1,J)=ATAN(Y/COS(DELTA(1,J)))

```

```

DELT A(2,J)=DFG(DELT A(1,J))
PSI(2,J)=DFG(PSI(1,J))
IF(PSI(2,J)<.500,.401,.401
500 PSI(2,J)=-PSI(2,J)
DELT A(2,J)=DELT A(2,J)+360.
IF(DELT A(2,J)-360.0)402,402,700.
700 DELTA(2,J)=DELT A(2,J)-360.
402 GO TO 300
401 DELTA(2,J)=DELT A(2,J)+180.
300 CONTINUE
PRINT 110, RNX(I)
110 FORMAT('1'T33,'INDX OF REFRACTION ='F6.3/10'3('SMALL'2RX1/
11X3('DELT A6X'DELTA!7X!PSI!7X1/')
400 DO 501 J=1,30
501 PRINT 120, DEL(1,J),DELT A(2,J),PSI(2,J),DEL(1,J+30),DELT A(2,J+30),
1PSI(2,J+30),DEL(1,J+60),DELT A(2,J+60),PSI(2,J+60)
120 FORMAT(1X3(F5.1,4X,F7.3,4X,F7.3,6X))
1000 PRINT 130, DEL(1,91),DELT A(2,91),PSI(2,91)
130 FORMAT(T68,F5.1,4X,F7.3,4X,F7.3)
STOP
END DAFT SOURCE DECK
BEGIN DAFT SOURCE DECK
    SUBROUTINE POLMQR(RD,RE,RF,RG,X1,X2,RL,RO,RP,RNX1)
    RFG=(RF**2+RG**2)
    RL=(X1-RNX1*X2)/(X1+RNX1*X2)
    RO=(RD*RF+RE*RG)/RFG
    RP=(RF*RF-RD*RG)/RFG
    RETURN
END DAFT SOURCE DECK
BEGIN DAFT SOURCE DECK
    SUBROUTINE STUVWX(RL,RO,RP,CS2D,SN2D,W,X)
    RS=RL+RO*CS2D+RP*SN2D
    RT=RP*CS2D-RO*SN2D
    RU=1.+RL*RO*CS2D+RL*RP*SN2D
    RV=RL*RP*CS2D-RL*RO*SN2D
    RUV=RU**2+RV**2
    W=(RS*RU+RT*RV)/PUV
    X=(RT*RU-RS*RV)/PUV
    RETURN
END DAFT SOURCE DECK
END MULTIPLE DECK COMPILE

```

## APPENDIX II

Values of  $\Delta$  and  $\Psi$  as a function of film thickness on a substrate of silicon  
at  $70^\circ$  angle of incidence for  $\lambda 5461 \text{ \AA}^\circ$

## INDEX OF REFRACTION = 1.0

SMALL DELTA	DELTA	PSI	SMALL DELTA	DELTA	PSI	SMALL DELTA	DELTA	PSI
0.0	175.038	11.763	60.0	179.038	11.763	120.0	179.038	11.763
2.0	175.038	11.763	62.0	179.038	11.763	122.0	179.038	11.763
4.0	175.038	11.763	64.0	179.038	11.763	124.0	179.038	11.763
6.0	175.038	11.763	66.0	179.038	11.763	126.0	179.038	11.763
8.0	175.038	11.763	68.0	179.038	11.763	128.0	179.038	11.763
10.0	175.038	11.763	70.0	179.038	11.763	130.0	179.038	11.763
12.0	175.038	11.763	72.0	179.038	11.763	132.0	179.038	11.763
14.0	175.038	11.763	74.0	179.038	11.763	134.0	179.038	11.763
16.0	175.038	11.763	76.0	179.038	11.763	136.0	179.038	11.763
18.0	175.038	11.763	78.0	179.038	11.763	138.0	179.038	11.763
20.0	175.038	11.763	80.0	179.038	11.763	140.0	179.038	11.763
22.0	175.038	11.763	82.0	179.038	11.763	142.0	179.038	11.763
24.0	175.038	11.763	84.0	179.038	11.763	144.0	179.038	11.763
26.0	175.038	11.763	86.0	179.038	11.763	146.0	179.038	11.763
28.0	175.038	11.763	88.0	179.038	11.763	148.0	179.038	11.763
30.0	175.038	11.763	90.0	179.038	11.763	150.0	179.038	11.763
32.0	175.038	11.763	92.0	179.038	11.763	152.0	179.038	11.763
34.0	175.038	11.763	94.0	179.038	11.763	154.0	179.038	11.763
36.0	175.038	11.763	96.0	179.038	11.763	156.0	179.038	11.763
38.0	175.038	11.763	98.0	179.038	11.763	158.0	179.038	11.763
40.0	175.038	11.763	100.0	179.038	11.763	160.0	179.038	11.763
42.0	175.038	11.763	102.0	179.038	11.763	162.0	179.038	11.763
44.0	175.038	11.763	104.0	179.038	11.763	164.0	179.038	11.763
46.0	175.038	11.763	106.0	179.038	11.763	166.0	179.038	11.763
48.0	175.038	11.763	108.0	179.038	11.763	168.0	179.038	11.763
50.0	175.038	11.763	110.0	179.038	11.763	170.0	179.038	11.763
52.0	175.038	11.763	112.0	179.038	11.763	172.0	179.038	11.763
54.0	175.038	11.763	114.0	179.038	11.763	174.0	179.038	11.763
56.0	175.038	11.763	116.0	179.038	11.763	176.0	179.038	11.763
58.0	175.038	11.763	118.0	179.038	11.763	178.0	179.038	11.763
						180.0	179.038	11.763

## INDEX OF REFRACTION = 1.1

SMALL DELTA	DELTA	PSI	SMALL DELTA	DELTA	PSI	SMALL DELTA	DELTA	PSI
0.0	175.038	11.763	60.0	128.895	30.377	120.0	230.680	30.267
2.0	175.330	11.629	62.0	130.812	31.644	122.0	232.353	29.587
4.0	167.761	11.958	64.0	132.954	31.703	124.0	233.808	28.901
6.0	162.405	12.265	66.0	135.327	32.350	126.0	235.050	28.210
8.0	157.346	12.621	68.0	137.933	32.982	128.0	236.084	27.514
10.0	152.635	13.057	70.0	140.772	33.195	130.0	236.913	26.813
12.0	148.301	13.562	72.0	143.844	34.184	132.0	237.541	26.107
14.0	144.354	14.125	74.0	147.144	34.743	134.0	237.970	25.396
16.0	140.789	14.736	76.0	150.666	35.263	136.0	238.201	24.679
18.0	137.592	15.385	78.0	154.396	35.738	138.0	238.235	23.956
20.0	134.743	16.065	80.0	158.319	36.150	140.0	238.070	23.228
22.0	132.221	16.768	82.0	162.413	36.516	142.0	237.705	22.495
24.0	130.005	17.488	84.0	166.651	36.803	144.0	237.135	21.757
26.0	128.073	18.219	86.0	171.003	37.012	146.0	236.355	21.015
28.0	126.406	18.857	88.0	175.431	37.138	148.0	235.356	20.271
30.0	124.990	19.699	90.0	179.898	37.176	150.0	234.129	19.526
32.0	123.810	20.442	92.0	184.364	37.128	152.0	232.662	18.782
34.0	122.853	21.184	94.0	188.788	36.992	154.0	230.940	18.044
36.0	122.112	21.922	96.0	193.132	36.773	156.0	228.946	17.314
38.0	121.578	22.657	98.0	197.360	36.477	158.0	226.662	16.596
40.0	121.247	23.386	100.0	201.443	36.111	160.0	224.067	15.897
42.0	121.114	24.110	102.0	205.352	35.683	162.0	221.138	15.223
44.0	121.178	24.828	104.0	209.067	35.200	164.0	217.854	14.581
46.0	121.437	25.540	106.0	212.571	34.673	166.0	214.198	13.981
48.0	121.293	26.247	108.0	215.853	34.108	168.0	210.157	13.431
50.0	122.566	26.948	110.0	218.906	33.512	170.0	205.729	12.942
52.0	123.400	27.644	112.0	221.726	32.893	172.0	200.928	12.524
54.0	124.457	28.336	114.0	224.311	32.255	174.0	195.789	12.189
56.0	125.723	29.022	116.0	226.664	31.603	176.0	190.370	11.946
58.0	127.200	29.702	118.0	228.785	30.939	178.0	184.753	11.803
						180.0	179.038	11.763

## INDEX OF REFRACTION = 1.2

SMALL DELTA	DELTA	PSI	SMALL DELTA	DELTA	PSI	SMALL DELTA	DELTA	PSI
0.0	175.038	11.763	60.0	108.511	36.391	120.0	251.265	36.252
2.0	171.475	11.859	62.0	110.279	37.472	122.0	252.709	35.208
4.0	164.127	12.169	64.0	112.363	38.594	124.0	253.880	34.199
6.0	157.153	12.500	66.0	114.791	39.762	126.0	254.796	33.217
8.0	150.664	13.016	68.0	117.592	40.974	128.0	255.469	32.260
10.0	144.718	13.638	70.0	120.798	42.229	130.0	255.912	31.320
12.0	135.328	14.348	72.0	124.467	43.519	132.0	256.136	30.395
14.0	134.480	15.126	74.0	128.576	44.632	134.0	256.146	29.480
16.0	130.138	15.957	76.0	133.220	46.147	136.0	255.949	28.572
18.0	126.260	16.828	78.0	138.412	47.435	138.0	255.547	27.666
20.0	122.803	17.725	80.0	144.171	48.658	140.0	254.943	26.760
22.0	119.725	18.641	82.0	150.497	49.767	142.0	254.135	25.852
24.0	116.990	19.567	84.0	157.356	50.708	144.0	253.120	24.939
26.0	114.565	20.498	86.0	164.674	51.427	146.0	251.693	24.022
28.0	112.423	21.430	88.0	172.331	51.675	148.0	250.444	23.099
30.0	110.543	22.359	90.0	180.165	52.018	150.0	248.763	22.171
32.0	108.605	23.283	92.0	187.992	51.646	152.0	246.835	21.239
34.0	107.497	24.222	94.0	195.626	51.371	154.0	244.640	20.306
36.0	106.306	25.115	96.0	202.910	50.629	156.0	242.155	19.373
38.0	105.325	26.023	98.0	209.726	49.668	158.0	239.353	18.447
40.0	104.550	26.927	100.0	216.004	48.544	160.0	236.200	17.534
42.0	103.976	27.829	102.0	221.714	47.311	162.0	232.659	16.640
44.0	103.604	28.731	104.0	226.858	46.016	164.0	228.686	15.776
46.0	103.435	29.636	106.0	231.456	44.697	166.0	224.239	14.954
48.0	103.473	30.547	108.0	235.541	43.382	168.0	219.277	14.189
50.0	103.723	31.469	110.0	239.148	42.90	170.0	213.768	13.496
52.0	104.194	32.466	112.0	242.317	40.835	172.0	207.701	12.894
54.0	104.295	33.361	114.0	245.082	39.623	174.0	201.100	12.404
56.0	105.388	34.341	116.0	247.475	38.456	176.0	194.034	12.042
58.0	107.038	35.349	118.0	249.528	37.333	178.0	186.623	11.825
						180.0	179.038	11.763

## INDEX OF REFRACTION = 1.3

SMALL DELTA	DELTA	PSI	SMALL DELTA	DELTA	PSI	SMALL DELTA	DELTA	PSI
0.0	175.038	11.763	60.0	95.164	38.588	120.0	264.657	38.415
2.0	170.785	11.869	62.0	96.337	39.534	122.0	265.522	37.157
4.0	162.778	12.143	64.0	97.813	41.276	124.0	266.135	35.969
6.0	155.196	12.573	66.0	99.628	42.530	126.0	266.512	34.837
8.0	148.159	13.138	68.0	101.823	44.610	128.0	266.669	33.752
10.0	141.723	13.816	70.0	104.453	46.427	130.0	266.616	32.705
12.0	135.895	14.586	72.0	107.585	48.192	132.0	266.362	31.687
14.0	130.648	15.426	74.0	111.322	50.507	134.0	265.914	30.691
16.0	125.932	16.320	76.0	115.771	52.761	136.0	265.276	29.711
18.0	121.701	17.252	78.0	121.095	55.126	138.0	264.450	28.740
20.0	117.903	18.210	80.0	127.471	57.545	140.0	263.439	27.775
22.0	114.491	19.184	82.0	135.142	59.518	142.0	262.231	26.811
24.0	111.423	20.167	84.0	144.322	62.100	144.0	260.833	25.846
26.0	108.663	21.152	86.0	155.128	63.892	146.0	259.234	24.878
28.0	106.183	22.137	88.0	167.397	65.074	148.0	257.425	23.904
30.0	103.957	23.118	90.0	180.545	65.461	150.0	255.392	22.926
32.0	101.967	24.093	92.0	193.643	64.986	152.0	253.120	21.942
34.0	100.196	25.063	94.0	205.783	63.732	154.0	250.587	20.955
36.0	98.633	26.027	96.0	216.425	61.888	156.0	247.769	19.968
38.0	97.269	26.989	98.0	225.464	59.676	158.0	244.635	18.985
40.0	96.096	27.949	100.0	232.973	57.290	160.0	241.148	18.012
42.0	95.112	28.911	102.0	239.237	54.870	162.0	237.265	17.058
44.0	94.315	29.870	104.0	244.457	52.511	164.0	232.939	16.132
46.0	93.705	30.857	106.0	248.826	50.267	166.0	228.118	15.247
48.0	93.284	31.851	108.0	252.491	48.164	168.0	222.752	14.419
50.0	93.058	32.868	110.0	255.570	46.211	170.0	216.797	13.666
52.0	93.033	33.916	112.0	258.151	44.404	172.0	210.233	13.009
54.0	93.218	35.001	114.0	260.302	42.735	174.0	203.075	12.471
56.0	93.625	36.134	116.0	262.077	41.190	176.0	195.392	12.072
58.0	94.267	37.326	118.0	263.517	39.755	178.0	187.316	11.832
						180.0	179.038	11.763

## INDEX OF REFRACTION = 1.4

SMALL DELTA	DELTA	PSI	SMALL DELTA	DELTA	PSI	SMALL DELTA	DELTA	PSI
0.0	175.038	11.763	60.0	85.511	39.015	120.0	274.288	38.811
2.0	170.623	11.867	62.0	85.977	40.492	122.0	274.511	37.452
4.0	162.448	12.138	64.0	86.673	42.102	124.0	274.533	36.183
6.0	154.689	12.562	66.0	87.621	43.867	126.0	274.366	34.987
8.0	147.465	13.120	68.0	88.849	45.816	128.0	274.017	33.851
10.0	140.829	13.790	70.0	90.394	47.577	130.0	273.492	32.763
12.0	134.791	14.552	72.0	92.307	50.383	132.0	272.796	31.711
14.0	125.322	15.384	74.0	94.664	53.063	134.0	271.932	30.688
16.0	124.381	16.270	76.0	97.577	56.443	136.0	270.901	29.686
18.0	119.916	17.195	78.0	101.225	59.336	138.0	269.702	28.699
20.0	115.276	18.147	80.0	105.907	62.932	140.0	268.334	27.721
22.0	112.215	19.115	82.0	112.152	66.176	142.0	266.792	26.747
24.0	108.891	20.094	84.0	120.931	70.726	144.0	265.070	25.775
26.0	105.866	21.077	86.0	134.041	74.475	146.0	263.160	24.801
28.0	103.117	22.060	88.0	154.169	77.391	148.0	261.051	23.825
30.0	100.612	23.040	90.0	181.613	78.463	150.0	258.730	22.845
32.0	98.333	24.018	92.0	208.443	77.119	152.0	256.178	21.862
34.0	96.263	24.991	94.0	227.610	74.055	154.0	253.374	20.877
36.0	94.389	25.961	96.0	240.077	70.256	156.0	250.293	19.894
38.0	92.701	26.931	98.0	248.481	66.304	158.0	246.903	18.915
40.0	91.190	27.902	100.0	254.500	62.482	160.0	243.167	17.940
42.0	89.851	28.877	102.0	259.037	58.917	162.0	239.043	17.000
44.0	88.681	29.864	104.0	262.584	55.659	164.0	234.482	16.082
46.0	87.678	30.865	106.0	265.421	52.713	166.0	229.434	15.205
48.0	86.641	31.888	108.0	267.719	50.064	168.0	223.849	14.386
50.0	86.172	32.940	110.0	269.583	47.866	170.0	217.686	13.641
52.0	85.673	34.031	112.0	271.085	45.548	172.0	210.924	12.992
54.0	85.351	35.170	114.0	272.275	43.620	174.0	203.579	12.461
56.0	85.210	36.371	116.0	273.189	41.872	176.0	195.720	12.068
58.0	85.261	37.647	118.0	273.853	40.277	178.0	187.477	11.831
						180.0	179.038	11.763

## INDEX OF REFRACTION = 1.460

SMALL DELTA	DELTA	PSI	SMALL DELTA	DELTA	PSI	SMALL DELTA	DELTA	PSI
0.0	179.038	11.763	60.0	80.912	38.762	120.0	278.058	38.543
2.0	170.666	11.864	62.0	80.959	40.269	122.0	278.708	37.165
4.0	162.520	12.175	64.0	81.183	41.916	124.0	278.394	35.882
6.0	154.770	12.534	66.0	81.593	43.732	126.0	277.920	34.676
8.0	147.528	13.073	68.0	82.199	45.747	128.0	277.289	33.533
10.0	140.850	13.722	70.0	83.015	47.996	130.0	276.504	32.440
12.0	134.748	14.460	72.0	84.059	50.520	132.0	275.566	31.386
14.0	129.197	15.269	74.0	85.358	53.358	134.0	274.476	30.364
16.0	124.159	16.132	76.0	86.954	56.551	136.0	273.232	29.363
18.0	119.585	17.034	78.0	88.920	60.137	138.0	271.832	28.379
20.0	115.428	17.965	80.0	91.389	64.139	140.0	270.274	27.406
22.0	111.643	18.914	82.0	94.631	68.557	142.0	268.551	26.439
24.0	108.188	19.874	84.0	99.280	73.352	144.0	266.656	25.474
26.0	105.030	20.840	86.0	107.156	78.401	146.0	264.581	24.510
28.0	102.137	21.807	88.0	125.555	83.319	148.0	262.313	23.545
30.0	99.485	22.774	90.0	185.228	85.946	150.0	259.839	22.578
32.0	97.054	23.739	92.0	237.920	82.725	152.0	257.140	21.609
34.0	94.825	24.702	94.0	253.986	77.741	154.0	254.195	20.640
36.0	92.786	25.664	96.0	261.243	72.711	156.0	250.977	19.673
38.0	90.925	26.626	98.0	265.648	67.958	158.0	247.456	18.714
40.0	89.233	27.591	100.0	268.765	63.590	160.0	243.596	17.767
42.0	87.704	28.563	102.0	271.126	59.640	162.0	239.355	16.841
44.0	86.333	29.546	104.0	273.067	56.104	164.0	234.686	15.945
46.0	85.116	30.546	106.0	274.621	52.956	166.0	229.562	15.032
48.0	84.052	31.570	108.0	275.883	50.159	168.0	223.876	14.296
50.0	83.140	32.675	110.0	276.894	47.670	170.0	217.651	13.575
52.0	82.380	33.721	112.0	277.686	45.450	172.0	210.850	12.947
54.0	81.774	34.869	114.0	278.257	43.463	174.0	203.492	12.434
56.0	81.325	36.041	116.0	278.639	41.666	176.0	195.644	12.056
58.0	81.036	37.171	118.0	278.837	40.035	178.0	187.434	11.828
						180.0	179.038	11.763

## INDEX OF REFRACTION = 1.487

SMALL DELTA	DELTA	PSI	SMALL DELTA	DELTA	PSI	SMALL DELTA	DELTA	PSI
0.0	179.038	11.763	0.0	79.073	38.559	120.0	280.680	38.333
2.0	170.708	11.862	62.0	78.934	43.368	122.0	280.370	36.954
4.0	162.597	12.117	64.0	78.957	41.720	124.0	279.911	35.671
6.0	154.869	12.517	66.0	79.132	43.542	126.0	279.306	34.466
8.0	147.636	13.046	68.0	79.464	45.566	128.0	278.554	33.324
10.0	140.753	13.612	70.0	79.357	47.830	130.0	277.658	32.233
12.0	134.833	14.415	72.0	80.611	50.372	132.0	276.616	31.182
14.0	129.254	15.273	74.0	81.429	53.236	134.0	275.429	30.162
16.0	124.180	16.093	76.0	82.415	56.467	136.0	274.095	29.166
18.0	119.564	16.742	78.0	83.575	60.103	138.0	272.610	28.185
20.0	115.360	17.860	80.0	84.926	64.177	140.0	270.970	27.217
22.0	111.523	18.797	82.0	86.514	68.699	142.0	269.170	26.255
24.0	108.014	19.746	84.0	88.454	73.653	144.0	267.202	25.296
26.0	104.798	20.702	86.0	91.144	78.980	146.0	265.057	24.339
28.0	101.846	21.660	88.0	96.726	84.569	148.0	262.722	23.381
30.0	99.132	22.618	90.0	206.645	89.136	150.0	260.182	22.421
32.0	96.635	23.576	92.0	264.280	83.811	152.0	257.421	21.461
34.0	94.339	24.531	94.0	269.101	78.247	154.0	254.416	20.502
36.0	92.230	25.487	96.0	271.641	72.963	156.0	251.141	19.546
38.0	90.295	26.443	98.0	273.521	68.062	158.0	247.565	18.598
40.0	88.527	27.403	100.0	275.072	63.597	160.0	243.654	17.663
42.0	86.917	28.371	102.0	276.395	59.581	162.0	239.365	16.750
44.0	85.460	29.350	104.0	277.530	55.998	164.0	234.654	15.867
46.0	84.152	30.347	106.0	278.491	52.817	166.0	229.475	15.027
48.0	82.991	31.368	108.0	279.285	49.996	168.0	223.781	14.245
50.0	81.975	32.421	110.0	279.916	47.491	170.0	217.540	13.537
52.0	81.103	33.516	112.0	280.384	45.259	172.0	210.735	12.922
54.0	80.376	34.663	114.0	280.693	43.261	174.0	203.388	12.419
56.0	79.794	35.875	116.0	280.844	41.461	176.0	195.565	12.049
58.0	79.359	37.168	118.0	280.838	39.828	178.0	187.391	11.827
						180.0	179.038	11.763

## INDEX OF REFRACTION = 1.5

SMALL DELTA	DELTA	PSI	SMALL DELTA	DELTA	PSI	SMALL DELTA	DELTA	PSI
0.0	179.038	11.763	60.0	78.234	38.443	120.0	281.511	38.215
2.0	170.732	11.861	62.0	78.013	39.952	122.0	281.126	36.838
4.0	162.642	12.113	64.0	77.935	41.404	124.0	280.599	35.556
6.0	154.929	12.509	66.0	77.999	43.426	126.0	279.931	34.352
8.0	147.703	13.032	68.0	78.203	45.451	128.0	279.123	33.212
10.0	141.020	13.662	70.0	78.542	47.716	130.0	278.174	32.122
12.0	134.893	14.381	72.0	79.013	50.260	132.0	277.084	31.073
14.0	129.303	15.169	74.0	79.604	53.128	134.0	275.852	30.055
16.0	124.213	16.012	76.0	80.300	56.364	136.0	274.475	29.061
18.0	119.577	16.894	78.0	81.077	60.008	138.0	272.949	28.083
20.0	115.351	17.805	80.0	81.895	64.091	140.0	271.272	27.117
22.0	111.491	18.736	82.0	82.684	68.627	142.0	269.436	26.158
24.0	107.957	19.679	84.0	83.292	73.597	144.0	267.433	25.203
26.0	104.714	20.630	86.0	83.285	78.543	146.0	265.255	24.249
28.0	101.733	21.583	88.0	80.482	84.354	148.0	262.888	23.294
30.0	98.990	22.537	90.0	332.866	89.132	150.0	260.318	22.339
32.0	96.464	23.490	92.0	278.493	83.181	152.0	257.528	21.384
34.0	94.136	24.442	94.0	276.451	78.195	154.0	254.494	20.430
36.0	91.994	25.394	96.0	276.579	72.892	156.0	251.192	19.479
38.0	90.025	26.343	98.0	277.226	67.977	158.0	247.592	18.537
40.0	88.220	27.304	100.0	278.024	63.500	160.0	243.656	17.609
42.0	86.572	28.269	102.0	278.839	59.475	162.0	239.346	16.702
44.0	85.074	29.246	104.0	279.606	55.687	164.0	234.616	15.826
46.0	83.724	30.241	106.0	280.287	52.701	166.0	229.421	14.994
48.0	82.517	31.260	108.0	280.866	49.878	168.0	223.716	14.219
50.0	81.452	32.312	110.0	281.311	47.371	170.0	217.469	13.517
52.0	80.528	33.405	112.0	281.631	45.139	172.0	210.665	12.909
54.0	79.743	34.551	114.0	281.813	43.141	174.0	203.326	12.412
56.0	79.099	35.762	116.0	281.854	41.342	176.0	195.519	12.046
58.0	78.596	37.054	118.0	281.754	39.709	178.0	187.367	11.826
						180.0	179.038	11.763

## INDEX OF REFRACTION = 1.6

SMALL DELTA	DELTA	PSI	SMALL DELTA	DELTA	PSI	SMALL DELTA	DELTA	PSI
0.0	179.638	11.763	60.0	72.642	37.252	120.0	287.027	37.007
2.0	176.988	11.851	62.0	71.812	38.721	122.0	286.103	35.665
4.0	163.122	12.079	64.0	71.046	40.326	124.0	285.089	34.416
6.0	155.582	12.436	66.0	70.325	42.093	126.0	283.978	33.242
8.0	148.467	12.910	68.0	69.620	44.052	128.0	282.761	32.129
10.0	141.632	13.485	70.0	68.894	46.234	130.0	281.436	31.067
12.0	135.696	14.142	72.0	68.090	48.674	132.0	279.996	30.044
14.0	130.049	14.868	74.0	67.128	51.408	134.0	278.436	29.052
16.0	124.664	15.648	76.0	65.883	54.466	136.0	276.751	28.085
18.0	120.105	16.468	78.0	64.158	57.667	138.0	274.936	27.135
20.0	115.732	17.320	80.0	61.634	61.608	140.0	272.983	26.198
22.0	111.707	18.194	82.0	57.750	65.637	142.0	270.886	25.270
24.0	107.994	19.083	84.0	51.481	69.807	144.0	268.633	24.348
26.0	104.561	19.983	86.0	40.925	73.793	146.0	266.216	23.430
28.0	101.380	20.889	88.0	23.182	76.906	148.0	263.620	22.514
30.0	98.420	21.799	90.0	357.835	78.024	150.0	260.831	21.601
32.0	95.682	22.712	92.0	333.335	76.524	152.0	257.829	20.690
34.0	93.126	23.626	94.0	316.081	73.210	154.0	254.595	19.784
36.0	90.745	24.543	96.0	307.156	69.161	156.0	251.102	18.885
38.0	88.526	25.464	98.0	301.352	64.995	158.0	247.322	17.998
40.0	86.460	26.391	100.0	297.729	61.003	160.0	243.222	17.128
42.0	84.536	27.327	102.0	295.356	57.310	162.0	238.765	16.282
44.0	82.748	28.278	104.0	293.721	53.960	164.0	233.913	15.469
46.0	80.089	29.246	106.0	292.520	50.951	166.0	228.626	14.700
48.0	78.554	30.240	108.0	291.596	48.263	168.0	222.070	13.987
50.0	78.137	31.267	110.0	290.807	45.663	170.0	216.620	13.347
52.0	76.833	32.334	112.0	290.085	43.715	172.0	209.873	12.794
54.0	75.630	33.453	114.0	289.378	41.786	174.0	202.655	12.345
56.0	74.546	34.636	116.0	288.648	40.044	176.0	195.030	12.015
58.0	73.550	35.896	118.0	287.871	38.459	178.0	187.109	11.819
						180.0	179.038	11.763

## INDEX OF REFRACTION = 1.7

SMALL DELTA	DELTA	PSI	SMALL DELTA	DELTA	PSI	SMALL DELTA	DELTA	PSI
0.0	179.038	11.763	60.0	68.322	35.653	120.0	291.260	35.398
2.0	171.324	11.841	62.0	66.972	37.137	122.0	289.871	34.129
4.0	163.763	12.041	64.0	65.628	38.540	124.0	288.433	32.943
6.0	156.472	12.356	66.0	64.258	40.182	126.0	286.931	31.824
8.0	149.540	12.776	68.0	62.821	41.987	128.0	285.355	30.762
10.0	143.020	13.287	70.0	61.261	43.576	130.0	283.695	29.746
12.0	136.534	13.876	72.0	59.503	46.171	132.0	281.942	28.767
14.0	131.282	14.530	74.0	57.440	48.591	134.0	280.088	27.818
16.0	126.047	15.236	76.0	54.924	51.242	136.0	278.127	26.892
18.0	121.202	15.984	78.0	51.746	54.113	138.0	276.050	25.984
20.0	116.715	16.764	80.0	47.611	57.156	140.0	273.848	25.089
22.0	112.554	17.570	82.0	42.112	60.269	142.0	271.513	24.205
24.0	108.680	18.393	84.0	34.731	63.263	144.0	269.034	23.329
26.0	105.088	19.230	86.0	24.957	65.638	146.0	266.399	22.459
28.0	101.729	20.077	88.0	12.660	67.595	148.0	263.596	21.594
30.0	98.587	20.932	90.0	358.681	68.192	150.0	260.607	20.734
32.0	95.644	21.791	92.0	344.891	67.386	152.0	257.417	19.880
34.0	92.881	22.656	94.0	333.004	65.437	154.0	254.003	19.034
36.0	90.283	23.526	96.0	323.670	62.761	156.0	250.343	18.199
38.0	87.838	24.402	98.0	316.654	59.727	158.0	246.409	17.379
40.0	85.534	25.286	100.0	311.424	56.413	160.0	242.174	16.578
42.0	83.361	26.181	102.0	307.479	53.592	162.0	237.604	15.804
44.0	81.311	27.090	104.0	304.433	50.756	164.0	232.668	15.065
46.0	79.374	28.018	106.0	302.007	48.143	166.0	227.336	14.369
48.0	77.544	28.970	108.0	300.005	45.761	168.0	221.581	13.730
50.0	75.812	29.953	110.0	298.286	43.600	170.0	215.391	13.158
52.0	74.171	30.975	112.0	296.751	41.643	172.0	208.768	12.667
54.0	72.612	32.044	114.0	295.327	39.866	174.0	201.744	12.271
56.0	71.126	33.172	116.0	293.961	38.240	176.0	194.379	11.983
58.0	69.701	34.370	118.0	292.615	36.765	178.0	186.770	11.811
						180.0	179.038	11.763

## INDEX OF REFRACTION = 1.8

SMALL DELTA	DELTA	PSI	SMALL DELTA	DELTA	PSI	SMALL DELTA	DELTA	PSI
0.0	179.038	11.763	60.0	65.002	33.781	120.0	294.484	33.523
2.0	171.703	11.831	62.0	63.216	35.052	122.0	292.699	32.350
4.0	164.491	12.003	64.0	61.397	38.421	124.0	290.893	31.246
6.0	157.498	12.276	66.0	59.511	37.902	126.0	289.049	30.201
8.0	150.799	12.640	68.0	57.512	39.510	128.0	287.153	29.205
10.0	144.442	13.086	70.0	55.342	41.256	130.0	285.193	28.250
12.0	138.455	13.603	72.0	52.027	43.152	132.0	283.158	27.328
14.0	132.842	14.181	74.0	50.171	45.199	134.0	281.039	26.434
16.0	127.597	14.809	76.0	46.949	47.387	136.0	278.825	25.561
18.0	122.700	15.478	78.0	43.109	49.687	138.0	276.507	24.706
20.0	118.129	16.181	80.0	38.466	52.039	140.0	274.076	23.865
22.0	113.859	16.910	82.0	32.818	54.341	142.0	271.522	23.035
24.0	109.863	17.660	84.0	25.989	56.442	144.0	268.834	22.215
26.0	106.117	18.427	86.0	17.914	58.150	146.0	265.999	21.403
28.0	102.598	19.266	88.0	8.753	59.252	148.0	263.005	20.598
30.0	99.285	19.995	90.0	358.973	59.586	150.0	259.835	19.801
32.0	96.160	20.793	92.0	349.263	59.995	152.0	256.472	19.013
34.0	93.207	21.598	94.0	340.284	57.859	154.0	252.898	18.236
36.0	90.410	22.411	96.0	332.449	56.058	156.0	249.092	17.473
38.0	87.756	23.232	98.0	325.853	53.502	158.0	245.029	16.727
40.0	85.233	24.063	100.0	320.413	51.579	160.0	240.685	16.003
42.0	82.831	24.905	102.0	315.936	49.229	162.0	236.034	15.307
44.0	80.540	25.762	104.0	312.230	46.545	164.0	231.051	14.647
46.0	78.349	26.637	106.0	309.108	44.781	166.0	225.714	14.031
48.0	76.251	27.535	108.0	306.424	42.761	168.0	220.007	13.467
50.0	74.236	28.461	110.0	304.062	40.893	170.0	213.924	12.967
52.0	72.293	29.422	112.0	301.926	39.172	172.0	207.477	12.540
54.0	70.412	30.425	114.0	299.953	37.589	174.0	200.698	12.198
56.0	68.580	31.480	116.0	298.081	36.129	176.0	193.641	11.950
58.0	66.782	32.594	118.0	296.269	34.779	178.0	186.388	11.803
						180.0	179.038	11.763

## INDEX OF REFRACTION = 1.9

SMALL DELTA	DELTA	PSI	SMALL DELTA	DELTA	PSI	SMALL DELTA	DELTA	PSI
0.0	179.038	11.763	60.0	62.495	31.728	120.0	296.886	31.473
2.0	172.103	11.821	62.0	60.345	32.672	122.0	294.762	30.408
4.0	165.265	11.967	64.0	58.141	34.092	124.0	292.636	29.400
6.0	158.596	12.199	66.0	55.848	35.396	126.0	290.490	28.440
8.0	152.166	12.509	68.0	53.425	36.793	128.0	288.309	27.522
10.0	146.012	12.891	70.0	50.820	38.288	130.0	286.078	26.639
12.0	140.163	13.337	72.0	47.970	39.881	132.0	283.786	25.785
14.0	134.629	13.838	74.0	44.799	41.565	134.0	281.421	24.955
16.0	129.411	14.386	76.0	41.220	43.323	136.0	278.974	24.145
18.0	124.497	14.975	78.0	37.136	45.120	138.0	276.433	23.352
20.0	119.872	15.597	80.0	32.446	46.901	140.0	273.789	22.574
22.0	115.519	16.246	82.0	27.065	48.586	142.0	271.031	21.807
24.0	111.416	16.917	84.0	20.950	50.071	144.0	268.148	21.051
26.0	107.544	17.607	86.0	14.136	51.236	146.0	265.127	20.304
28.0	103.883	18.312	88.0	6.768	51.566	148.0	261.955	19.568
30.0	100.416	19.630	90.0	359.106	52.180	150.0	258.619	18.841
32.0	97.123	19.758	92.0	351.480	51.650	152.0	255.101	18.126
34.0	93.595	20.497	94.0	344.211	51.017	154.0	251.386	17.424
36.0	91.012	21.244	96.0	337.538	49.773	156.0	247.454	16.738
38.0	88.163	22.002	98.0	331.579	48.235	158.0	243.285	16.071
40.0	85.436	22.770	100.0	326.350	46.520	160.0	238.861	15.428
42.0	82.821	23.551	102.0	321.797	44.728	162.0	234.160	14.815
44.0	80.306	24.346	104.0	317.027	42.934	164.0	229.166	14.236
46.0	77.882	25.159	106.0	314.342	41.188	166.0	223.863	13.699
48.0	75.537	25.992	108.0	311.246	39.521	168.0	218.243	13.212
50.0	73.263	26.851	110.0	308.452	37.947	170.0	212.310	12.782
52.0	71.047	27.740	112.0	305.889	36.472	172.0	206.078	12.418
54.0	68.878	28.665	114.0	303.496	35.094	174.0	199.577	12.128
56.0	66.741	29.633	116.0	301.223	33.807	176.0	192.858	11.919
58.0	64.620	30.651	118.0	299.031	32.603	178.0	185.985	11.796
						180.0	179.038	11.763

## INDEX OF REFRACTION = 2.0

SMALL DELTA	DELTA	PSI	SMALL DELTA	DELTA	PSI	SMALL DELTA	DELTA	PSI
0.0	179.038	11.763	60.0	60.676	29.558	120.0	298.595	29.311
2.0	172.511	11.811	62.0	58.218	30.570	122.0	296.177	28.362
4.0	166.057	11.933	64.0	55.698	31.637	124.0	293.770	27.457
6.0	159.735	12.126	66.0	53.083	32.164	126.0	291.354	26.591
8.0	153.595	12.386	68.0	50.338	33.955	128.0	288.913	25.759
10.0	147.674	12.707	70.0	47.419	35.210	130.0	286.435	24.955
12.0	141.598	13.084	72.0	44.275	36.523	132.0	283.905	24.177
14.0	136.579	13.511	74.0	40.864	37.684	134.0	281.313	23.420
16.0	131.423	13.980	76.0	37.114	39.274	136.0	278.667	22.682
18.0	126.525	14.488	78.0	32.972	40.660	138.0	275.897	21.959
20.0	121.879	15.027	80.0	28.385	41.599	140.0	273.053	21.250
22.0	117.470	15.594	82.0	23.333	41.233	142.0	270.103	20.553
24.0	113.285	16.185	84.0	17.807	44.292	144.0	267.037	19.868
26.0	109.308	16.794	86.0	11.860	45.104	146.0	263.843	19.194
28.0	105.524	17.421	88.0	5.596	45.603	148.0	260.509	18.532
30.0	101.618	18.062	90.0	359.172	45.744	150.0	257.021	17.881
32.0	98.476	18.715	92.0	352.769	45.515	152.0	253.365	17.243
34.0	95.183	19.380	94.0	346.568	44.936	154.0	249.528	16.621
36.0	92.226	20.057	96.0	340.712	44.059	156.0	245.493	16.016
38.0	88.595	20.744	98.0	335.293	42.551	158.0	241.245	15.431
40.0	86.077	21.442	100.0	330.349	41.685	160.0	236.769	14.871
42.0	83.260	22.154	102.0	325.872	40.329	162.0	232.052	14.340
44.0	80.536	22.879	104.0	321.826	38.537	164.0	227.081	13.843
46.0	77.893	23.621	106.0	318.159	37.551	166.0	221.849	13.384
48.0	75.320	24.382	108.0	314.812	36.198	168.0	216.355	12.971
50.0	72.807	25.165	110.0	311.728	34.697	170.0	210.606	12.610
52.0	70.342	25.973	112.0	308.853	33.656	172.0	204.619	12.305
54.0	67.912	26.812	114.0	306.140	32.479	174.0	198.422	12.064
56.0	65.502	27.686	116.0	303.545	31.365	176.0	192.057	11.891
58.0	63.096	28.600	118.0	301.044	30.310	178.0	185.575	11.790
						180.0	179.038	11.763

## INDEX OF REFRACTION = 2.2

SMALL DELTA	DELTA	PSI	SMALL DELTA	DELTA	PSI	SMALL DELTA	DELTA	PSI
0.0	179.038	11.763	60.0	58.785	25.062	120.0	300.230	24.842
2.0	173.319	11.795	62.0	55.834	25.069	122.0	297.322	24.128
4.0	167.640	11.874	64.0	52.818	26.581	124.0	294.431	23.439
6.0	162.031	12.000	66.0	49.720	27.380	126.0	291.543	22.772
8.0	156.520	12.170	68.0	46.517	28.203	128.0	288.643	22.127
10.0	151.133	12.383	70.0	43.182	29.445	130.0	285.718	21.501
12.0	145.087	12.634	72.0	39.691	29.899	132.0	282.757	20.892
14.0	140.795	12.923	74.0	36.017	30.755	134.0	279.748	20.299
16.0	135.867	13.244	76.0	32.138	31.596	136.0	276.681	19.721
18.0	131.107	13.596	78.0	28.036	32.404	138.0	273.547	19.156
20.0	126.515	13.975	80.0	23.703	33.155	140.0	270.336	18.604
22.0	122.099	14.378	82.0	19.140	33.820	142.0	267.038	18.065
24.0	117.024	14.804	84.0	14.366	34.371	144.0	263.644	17.538
26.0	113.714	15.248	86.0	9.415	34.781	146.0	260.145	17.023
28.0	109.751	15.711	88.0	4.336	35.025	148.0	256.532	16.521
30.0	105.926	16.189	90.0	359.202	35.091	150.0	252.795	16.033
32.0	102.231	16.681	92.0	354.075	34.972	152.0	248.925	15.559
34.0	98.657	17.187	94.0	349.028	34.670	154.0	244.914	15.102
36.0	95.194	17.705	96.0	344.122	34.225	156.0	240.754	14.663
38.0	91.833	18.236	98.0	339.405	33.637	158.0	236.436	14.245
40.0	88.565	18.778	100.0	334.905	32.544	160.0	231.956	13.849
42.0	85.301	19.333	102.0	330.637	32.173	162.0	227.308	13.478
44.0	82.271	19.901	104.0	326.600	31.353	164.0	222.492	13.136
46.0	79.225	20.483	106.0	322.780	30.504	166.0	217.510	12.825
48.0	76.234	21.080	108.0	319.160	29.647	168.0	212.366	12.548
50.0	73.267	21.693	110.0	315.714	28.795	170.0	207.071	12.309
52.0	70.373	22.324	112.0	312.418	27.957	172.0	201.641	12.110
54.0	67.481	22.975	114.0	309.246	27.140	174.0	196.095	11.954
56.0	64.595	23.647	116.0	306.172	26.347	176.0	190.459	11.843
58.0	61.704	24.342	118.0	303.174	25.581	178.0	184.763	11.779
						180.0	179.038	11.763

## INDEX OF REFRACTION = 2.4

SMALL DELTA	DELTA	PSI	SMALL DELTA	DELTA	PSI	SMALL DELTA	DELTA	PSI
0.0	179.038	11.763	60.0	59.046	20.576	120.0	299.659	20.399
2.0	174.096	11.782	62.0	55.676	21.077	122.0	296.320	19.913
4.0	169.171	11.827	64.0	52.256	21.587	124.0	293.014	19.440
6.0	164.277	11.899	66.0	48.774	22.106	126.0	289.706	18.979
8.0	159.427	11.997	68.0	45.218	22.629	128.0	286.394	18.530
10.0	154.633	12.120	70.0	41.573	23.153	130.0	283.067	18.094
12.0	149.905	12.267	72.0	37.827	23.672	132.0	279.716	17.669
14.0	145.252	12.437	74.0	33.969	24.178	134.0	276.333	17.256
16.0	140.681	12.628	76.0	29.990	24.663	136.0	272.910	16.855
18.0	136.196	12.841	78.0	25.888	25.115	138.0	269.440	16.464
20.0	131.803	13.073	80.0	21.661	25.525	140.0	265.914	16.085
22.0	127.501	13.323	82.0	17.318	25.879	142.0	262.328	15.717
24.0	123.293	13.589	84.0	12.872	26.165	144.0	258.675	15.361
26.0	119.177	13.872	86.0	8.342	26.374	146.0	254.950	15.016
28.0	115.151	14.170	88.0	3.756	26.496	148.0	251.147	14.683
30.0	111.214	14.481	90.0	359.142	26.526	150.0	247.262	14.363
32.0	107.361	14.806	92.0	354.535	26.463	152.0	243.291	14.056
34.0	103.589	15.143	94.0	349.964	26.310	154.0	239.231	13.764
36.0	99.892	15.492	96.0	345.460	26.073	156.0	235.079	13.487
38.0	96.266	15.853	98.0	341.047	25.762	158.0	230.835	13.226
40.0	92.704	16.225	100.0	336.742	25.387	160.0	226.498	12.983
42.0	89.202	16.607	102.0	332.557	24.961	162.0	222.069	12.758
44.0	85.751	17.002	104.0	328.497	24.495	164.0	217.550	12.553
46.0	82.345	17.407	106.0	324.556	24.001	166.0	212.947	12.370
48.0	78.577	17.823	108.0	320.740	23.489	168.0	208.264	12.208
50.0	75.637	18.252	110.0	317.025	22.968	170.0	203.510	12.070
52.0	72.319	18.692	112.0	313.414	22.443	172.0	198.693	11.957
54.0	69.011	19.145	114.0	309.884	21.920	174.0	193.825	11.869
56.0	65.704	19.609	116.0	306.424	21.404	176.0	188.917	11.807
58.0	62.387	20.087	118.0	303.020	20.896	178.0	183.983	11.772
						180.0	179.038	11.763

## INDEX OF REFRACTION = 2.6

SMALL DELTA	DELTA	PSI	SMALL DELTA	DELTA	PSI	SMALL DELTA	DELTA	PSI
0.0	175.038	11.763	60.0	61.680	16.299	120.0	296.617	16.182
2.0	174.830	11.771	62.0	57.901	16.576	122.0	292.881	15.912
4.0	170.626	11.751	64.0	54.081	16.657	124.0	289.167	15.649
6.0	166.431	11.822	66.0	50.214	17.139	126.0	285.469	15.392
8.0	162.247	11.863	68.0	46.293	17.421	128.0	281.780	15.143
10.0	158.060	11.916	70.0	42.311	17.699	130.0	278.094	14.901
12.0	153.930	11.980	72.0	38.264	17.570	132.0	274.405	14.668
14.0	149.802	12.055	74.0	34.146	16.231	134.0	270.710	14.443
16.0	145.699	12.140	76.0	29.956	16.476	136.0	267.002	14.226
18.0	141.621	12.235	78.0	25.695	16.702	138.0	263.278	14.017
20.0	137.572	12.340	80.0	21.365	16.902	140.0	259.535	13.817
22.0	133.553	12.455	82.0	16.973	16.973	142.0	255.770	13.625
24.0	129.564	12.580	84.0	12.927	16.209	144.0	251.979	13.441
26.0	125.607	12.715	86.0	8.030	16.306	146.0	248.162	13.266
28.0	121.681	12.856	88.0	3.521	16.362	148.0	244.315	13.100
30.0	117.787	13.010	90.0	358.991	19.373	150.0	240.437	12.942
32.0	113.924	13.172	92.0	354.465	19.344	152.0	236.529	12.794
34.0	110.091	13.342	94.0	349.958	19.270	154.0	232.589	12.654
36.0	106.286	13.520	96.0	345.485	19.156	156.0	228.617	12.524
38.0	102.508	13.708	98.0	341.060	19.005	158.0	224.814	12.403
40.0	98.753	13.903	100.0	336.692	18.821	160.0	220.581	12.293
42.0	95.020	14.107	102.0	332.390	18.609	162.0	216.519	12.192
44.0	91.305	14.319	104.0	328.158	18.375	164.0	212.429	12.101
46.0	87.604	14.539	106.0	323.998	18.122	166.0	208.314	12.020
48.0	83.913	14.768	108.0	319.909	17.856	168.0	204.176	11.951
50.0	80.226	15.003	110.0	315.888	17.582	170.0	200.010	11.892
52.0	76.542	15.249	112.0	311.932	17.301	172.0	195.843	11.844
54.0	72.851	15.501	114.0	308.033	17.019	174.0	191.654	11.807
56.0	69.148	15.761	116.0	304.186	16.737	176.0	187.454	11.781
58.0	65.427	16.027	118.0	300.383	16.458	178.0	183.248	11.766
						180.0	179.030	11.763

## INDEX OF REFRACTION = 2.8

SMALL DELTA	DELTA	PSI	SMALL DELTA	DELTA	PSI	SMALL DELTA	DELTA	PSI
0.0	175.038	11.763	60.0	67.632	12.405	120.0	290.107	12.372
2.0	175.320	11.763	62.0	63.428	12.474	122.0	285.986	12.308
4.0	172.000	11.764	64.0	59.167	12.546	124.0	281.917	12.248
6.0	168.478	11.764	66.0	54.846	12.621	126.0	277.895	12.192
8.0	164.533	11.765	68.0	50.462	12.697	128.0	273.910	12.141
10.0	161.423	11.767	70.0	46.017	12.773	130.0	269.983	12.093
12.0	157.887	11.769	72.0	41.508	12.848	132.0	266.088	12.051
14.0	154.345	11.771	74.0	36.938	12.921	134.0	262.229	12.012
16.0	150.795	11.774	76.0	32.307	12.990	136.0	258.404	11.977
18.0	147.235	11.778	78.0	27.621	13.053	138.0	254.611	11.946
20.0	143.666	11.783	80.0	22.883	13.110	140.0	250.846	11.918
22.0	140.089	11.790	82.0	18.099	13.158	142.0	247.109	11.894
24.0	136.491	11.797	84.0	13.279	13.196	144.0	243.397	11.872
26.0	132.803	11.806	86.0	8.430	13.223	146.0	239.707	11.854
28.0	129.260	11.817	88.0	3.562	13.238	148.0	236.039	11.838
30.0	125.620	11.829	90.0	358.686	13.242	150.0	232.390	11.824
32.0	121.960	11.844	92.0	353.813	13.232	152.0	228.758	11.812
34.0	118.201	11.861	94.0	348.953	13.211	154.0	225.144	11.802
36.0	114.500	11.881	96.0	344.118	13.178	156.0	221.543	11.794
38.0	110.654	11.904	98.0	339.315	13.135	158.0	217.957	11.787
40.0	107.103	11.930	100.0	334.554	13.082	160.0	214.382	11.782
42.0	103.324	11.960	102.0	329.842	13.022	162.0	210.818	11.777
44.0	99.514	11.993	104.0	325.184	12.956	164.0	207.264	11.773
46.0	95.672	12.030	106.0	320.584	12.885	166.0	203.718	11.770
48.0	91.794	12.071	108.0	316.045	12.811	168.0	200.179	11.768
50.0	87.879	12.116	110.0	311.568	12.735	170.0	196.647	11.766
52.0	83.923	12.165	112.0	307.155	12.659	172.0	193.119	11.765
54.0	79.623	12.219	114.0	302.804	12.584	174.0	189.596	11.764
56.0	75.876	12.277	116.0	298.513	12.511	176.0	186.075	11.764
58.0	71.780	12.339	118.0	294.282	12.440	178.0	182.556	11.763
						180.0	179.030	11.763

## INDEX OF REFRACTION = 3.0

SMALL DELTA	DELTA	PSI	SMALL DELTA	DELTA	PSI	SMALL DELTA	DELTA	PSI
0.0	176.038	11.763	60.0	79.147	9.115	120.0	277.920	9.206
2.0	176.169	11.757	62.0	74.642	9.903	122.0	273.630	9.341
4.0	173.296	11.745	64.0	70.000	8.834	124.0	269.461	9.476
6.0	170.417	11.725	66.0	65.218	8.729	126.0	265.406	9.612
8.0	167.531	11.698	68.0	60.291	8.608	128.0	261.459	9.746
10.0	164.635	11.665	70.0	55.218	8.493	130.0	257.614	9.880
12.0	161.727	11.625	72.0	50.003	8.385	132.0	253.862	10.011
14.0	158.803	11.578	74.0	44.645	8.285	134.0	250.199	10.140
16.0	155.062	11.525	76.0	39.151	8.193	136.0	246.617	10.267
18.0	152.900	11.465	78.0	33.530	8.112	138.0	243.111	10.390
20.0	149.515	11.359	80.0	27.793	8.043	140.0	239.674	10.510
22.0	146.504	11.326	82.0	21.956	7.985	142.0	236.301	10.626
24.0	143.663	11.248	84.0	16.036	7.940	144.0	232.988	10.737
26.0	140.790	11.163	86.0	10.053	7.899	146.0	229.729	10.844
28.0	137.680	11.074	88.0	4.030	7.893	148.0	226.919	10.947
30.0	134.531	10.978	90.0	357.991	7.890	150.0	223.355	11.044
32.0	131.337	10.878	92.0	351.960	7.902	152.0	220.233	11.135
34.0	128.695	10.772	94.0	345.961	7.929	154.0	217.147	11.221
36.0	124.801	10.662	96.0	340.017	7.969	156.0	214.096	11.302
38.0	121.449	10.548	98.0	334.150	8.023	158.0	211.075	11.376
40.0	118.035	10.429	100.0	328.377	8.089	160.0	208.082	11.444
42.0	114.552	10.307	102.0	322.715	8.166	162.0	205.113	11.506
44.0	110.597	10.181	104.0	317.177	8.255	164.0	202.165	11.562
46.0	107.361	10.053	106.0	311.772	8.352	166.0	199.235	11.610
48.0	103.641	9.922	108.0	306.507	8.458	168.0	196.322	11.653
50.0	99.828	9.789	110.0	301.386	8.571	170.0	193.422	11.688
52.0	95.516	9.655	112.0	296.410	8.690	172.0	190.533	11.717
54.0	91.899	9.519	114.0	291.578	8.814	174.0	187.652	11.739
56.0	87.770	9.384	116.0	286.885	8.942	176.0	184.778	11.754
58.0	83.521	9.249	118.0	282.338	9.073	178.0	181.907	11.762
						180.0	179.038	11.763

## INDEX OF REFRACTION = 3.2

SMALL DELTA	DELTA	PSI	SMALL DELTA	DELTA	PSI	SMALL DELTA	DELTA	PSI
0.C	175.038	11.763	60.C	29.967	6.842	120.0	256.901	7.103
2.C	176.779	11.753	62.C	96.097	6.530	122.0	253.364	7.403
4.C	174.518	11.732	64.0	92.006	6.112	124.0	249.976	7.695
6.C	172.253	11.700	66.0	87.658	5.891	126.0	246.718	7.979
8.C	169.982	11.658	68.0	83.010	5.569	128.0	243.575	8.253
10.C	167.704	11.604	70.0	78.010	5.247	130.0	240.534	8.519
12.C	165.418	11.540	72.0	72.596	4.920	132.0	237.583	8.774
14.C	163.121	11.465	74.0	66.696	4.617	134.0	234.712	9.020
16.C	160.811	11.379	76.0	60.228	4.318	136.0	231.913	9.256
18.C	158.487	11.283	78.0	53.104	4.037	138.0	229.178	9.481
20.0	156.147	11.175	80.0	45.241	3.781	140.0	226.501	9.697
22.0	153.187	11.057	82.0	36.582	3.558	142.0	223.876	9.901
24.0	151.407	10.928	84.0	27.123	3.378	144.0	221.297	10.096
26.0	149.022	10.789	86.0	16.950	3.249	146.0	218.759	10.280
28.0	146.571	10.638	88.0	6.267	3.180	148.0	216.260	10.453
30.0	144.110	10.477	90.0	355.380	3.175	150.0	213.794	10.615
32.0	141.616	10.305	92.0	344.644	3.235	152.0	211.358	10.767
34.0	139.085	10.123	94.0	334.379	3.355	154.0	208.950	10.908
36.0	136.513	9.930	96.0	324.803	3.528	156.0	206.566	11.039
38.0	133.895	9.727	98.0	316.021	3.745	158.0	204.203	11.159
40.0	131.227	9.513	100.0	308.041	3.597	160.0	201.860	11.268
42.0	128.501	9.289	102.0	300.810	4.275	162.0	199.533	11.366
44.0	125.713	9.055	104.0	294.248	4.571	164.0	197.222	11.453
46.0	122.854	8.811	106.0	288.267	4.881	166.0	194.923	11.530
48.0	119.916	8.557	108.0	282.784	5.199	168.0	192.635	11.596
50.0	116.289	8.293	110.0	277.726	5.521	170.0	190.356	11.651
52.0	113.763	8.020	112.0	273.027	5.844	172.0	188.084	11.695
54.0	110.524	7.737	114.0	268.636	6.165	174.0	185.818	11.728
56.0	107.157	7.447	116.0	264.509	6.483	176.0	183.556	11.751
58.0	103.645	7.148	118.0	260.607	6.796	178.0	181.297	11.762
						180.0	179.038	11.763

## INDEX OF REFRACTION = 3.4

SMALL DELTA	DELTA	PSI	SMALL DELTA	DELTA	PSI	SMALL DELTA	DELTA	PSI
0.0	179.038	11.763	60.0	129.361	6.195	120.0	228.970	6.599
2.C	177.356	11.750	62.0	127.967	5.831	122.0	227.452	6.941
4.C	175.673	11.726	64.0	126.659	5.457	124.0	225.894	7.273
6.C	173.590	11.689	66.0	125.460	5.074	126.0	224.306	7.593
8.C	172.307	11.641	68.0	124.406	4.683	128.0	222.694	7.902
10.C	170.624	11.580	70.0	123.546	4.285	130.0	221.063	8.200
12.0	168.539	11.508	72.0	122.951	3.881	132.0	219.417	8.486
14.0	167.255	11.423	74.0	122.718	3.473	134.0	217.759	8.760
16.0	165.569	11.327	76.0	123.005	3.062	136.0	216.093	9.022
18.0	163.883	11.219	78.0	124.061	2.653	138.0	214.420	9.272
20.0	162.197	11.099	80.0	126.300	2.250	140.0	212.741	9.511
22.0	160.509	10.967	82.0	130.449	1.861	142.0	211.059	9.737
24.0	158.822	10.823	84.0	137.797	1.504	144.0	209.375	9.952
26.0	157.134	10.666	86.0	140.421	1.209	146.0	207.689	10.154
28.0	155.446	10.498	88.0	170.024	1.037	148.0	206.001	10.345
30.0	153.758	10.318	90.0	193.127	1.051	150.0	204.313	10.523
32.0	152.071	10.126	92.0	211.774	1.245	152.0	202.625	10.690
34.0	150.385	9.922	94.0	223.508	1.551	154.0	200.937	10.844
36.0	148.701	9.706	96.0	230.297	1.915	156.0	199.249	10.986
38.0	147.020	9.477	98.0	234.115	2.306	158.0	197.562	11.117
40.0	145.343	9.237	100.0	236.152	2.711	160.0	195.876	11.235
42.0	143.671	8.985	102.0	237.075	3.120	162.0	194.190	11.342
44.0	142.006	8.721	104.0	237.281	3.531	164.0	192.504	11.436
46.0	140.350	8.445	106.0	236.988	3.939	166.0	190.820	11.519
48.0	138.706	8.158	108.0	236.345	4.342	168.0	189.135	11.590
50.0	137.078	7.859	110.0	235.456	4.739	170.0	187.452	11.648
52.0	135.469	7.548	112.0	234.382	5.129	172.0	185.769	11.695
54.0	133.885	7.226	114.0	233.166	5.510	174.0	184.086	11.730
56.0	132.333	6.893	116.0	231.843	5.883	176.0	182.403	11.753
58.0	130.821	6.549	118.0	230.439	6.246	178.0	180.721	11.764
						180.0	179.038	11.763

## INDEX OF REFRACTION = 3.6

SMALL DELTA	DELTA	PSI	SMALL DELTA	DELTA	PSI	SMALL DELTA	DELTA	PSI
0.C	179.038	11.763	60.0	154.695	7.184	120.0	205.398	7.610
2.C	177.902	11.749	62.0	154.459	6.931	122.0	205.270	7.860
4.C	176.769	11.724	64.0	155.402	6.681	124.0	205.025	8.106
6.C	175.638	11.689	66.0	156.042	6.435	126.0	204.675	8.351
8.C	174.513	11.643	68.0	156.901	6.195	128.0	204.232	8.589
10.C	173.393	11.587	70.0	157.998	5.964	130.0	203.706	8.821
12.C	172.280	11.521	72.0	159.353	5.743	132.0	203.107	9.047
14.C	171.176	11.444	74.0	160.981	5.537	134.0	202.443	9.267
16.C	170.082	11.356	76.0	162.892	5.347	136.0	201.720	9.479
18.C	168.599	11.259	78.0	165.089	5.179	138.0	200.945	9.683
20.0	167.531	11.151	80.0	167.562	5.033	140.0	200.124	9.878
22.0	166.877	11.033	82.0	170.287	4.815	142.0	199.262	10.065
24.0	165.241	10.905	84.0	173.225	4.627	144.0	198.363	10.244
26.0	164.825	10.768	86.0	176.321	4.771	146.0	197.432	10.413
28.0	163.831	10.620	88.0	179.505	4.748	148.0	196.471	10.573
30.0	162.862	10.463	90.0	182.701	4.760	150.0	195.484	10.723
32.0	161.521	10.297	92.0	185.831	4.606	152.0	194.475	10.864
34.0	161.012	10.121	94.0	188.825	4.884	154.0	193.444	10.995
36.0	160.138	9.937	96.0	191.621	4.594	156.0	192.396	11.116
38.C	159.304	9.744	98.0	194.175	5.131	158.0	191.332	11.227
40.C	158.514	9.542	100.0	196.455	5.293	160.0	190.253	11.327
42.C	157.775	9.333	102.0	198.459	5.476	162.0	189.163	11.418
44.C	157.092	9.116	104.0	200.174	5.678	164.0	188.061	11.498
46.C	156.472	8.892	106.0	201.612	5.894	166.0	186.951	11.568
48.C	155.523	8.661	108.0	202.787	6.123	168.0	185.833	11.627
50.0	155.453	8.425	110.0	203.717	6.360	170.0	184.709	11.676
52.C	155.074	8.183	112.0	204.423	6.605	172.0	183.580	11.715
54.C	154.795	7.937	114.0	204.925	6.694	174.0	182.447	11.743
56.C	154.629	7.668	116.0	205.242	7.106	176.0	181.312	11.760
58.0	154.591	7.436	118.0	205.394	7.158	178.0	180.175	11.767
						180.0	179.038	11.763

## INDEX OF REFRACTION = 3.0

SMALL DELTA	DELTA	PSI	SMALL DELTA	DELTA	PSI	SMALL DELTA	DELTA	PSI
0.0	176.038	11.763	60.0	170.076	9.009	120.0	190.726	9.397
2.0	176.422	11.749	62.0	170.467	9.091	122.0	190.857	9.526
4.0	177.010	11.727	64.0	170.924	9.176	124.0	190.928	9.656
6.0	177.204	11.699	66.0	171.446	9.271	126.0	190.943	9.786
8.0	176.604	11.664	68.0	172.033	9.370	128.0	190.904	9.915
10.0	176.014	11.621	70.0	172.682	9.476	130.0	190.814	10.044
12.0	175.434	11.573	72.0	173.370	9.591	132.0	190.675	10.170
14.0	174.866	11.517	74.0	174.154	9.714	134.0	190.490	10.294
16.0	174.312	11.455	76.0	174.969	9.847	136.0	190.262	10.416
18.0	173.774	11.387	78.0	175.828	9.991	138.0	189.993	10.534
20.0	173.253	11.312	80.0	176.726	9.145	140.0	189.687	10.649
22.0	172.752	11.232	82.0	177.654	9.110	142.0	189.345	10.760
24.0	172.273	11.146	84.0	178.605	9.087	144.0	188.971	10.866
26.0	171.818	11.054	86.0	179.568	9.075	146.0	188.567	10.968
28.0	171.380	10.957	88.0	180.536	9.076	148.0	188.134	11.064
30.0	170.987	10.855	90.0	181.499	9.089	150.0	187.676	11.155
32.0	170.616	10.748	92.0	182.447	9.113	152.0	187.194	11.241
34.0	170.278	10.637	94.0	183.373	9.149	154.0	186.691	11.321
36.0	169.976	10.522	96.0	184.267	9.196	156.0	186.169	11.395
38.0	169.712	10.403	98.0	185.122	9.254	158.0	185.629	11.462
40.0	169.488	10.281	100.0	185.931	9.322	160.0	185.073	11.523
42.0	169.308	10.156	102.0	186.695	9.400	162.0	184.504	11.578
44.0	169.174	10.030	104.0	187.392	9.486	164.0	183.922	11.626
46.0	169.089	9.911	106.0	188.034	9.581	166.0	183.331	11.668
48.0	169.056	9.772	108.0	188.613	9.682	168.0	182.731	11.702
50.0	169.077	9.642	110.0	189.129	9.790	170.0	182.124	11.730
52.0	169.155	9.512	112.0	189.578	9.904	172.0	181.511	11.751
54.0	169.291	9.383	114.0	189.962	9.922	174.0	180.895	11.764
56.0	169.490	9.256	116.0	190.281	9.944	176.0	180.276	11.771
58.0	169.751	9.131	118.0	190.535	9.969	178.0	179.657	11.771
						180.0	179.038	11.763

## INDEX OF REFRACTION = 4.0

SMALL DELTA	DELTA	PSI	SMALL DELTA	DELTA	PSI	SMALL DELTA	DELTA	PSI
0.0	176.038	11.763	60.0	178.905	81.774	120.0	182.053	11.417
2.0	176.516	11.749	62.0	179.034	81.660	122.0	182.044	11.444
4.0	178.803	11.734	64.0	179.168	81.448	124.0	182.025	11.472
6.0	178.693	11.717	66.0	179.306	81.337	126.0	181.997	11.499
8.0	178.589	11.699	68.0	179.449	81.229	128.0	181.959	11.526
10.0	178.492	11.679	70.0	179.594	81.122	130.0	181.912	11.552
12.0	178.400	11.658	72.0	179.742	81.018	132.0	181.857	11.578
14.0	178.317	11.636	74.0	179.891	81.115	134.0	181.792	11.602
16.0	178.240	11.613	76.0	180.040	81.115	136.0	181.720	11.626
18.0	178.172	11.589	78.0	180.190	81.116	138.0	181.639	11.648
20.0	178.112	11.564	80.0	180.338	81.200	140.0	181.551	11.670
22.0	178.061	11.538	82.0	180.485	81.025	142.0	181.457	11.690
24.0	178.019	11.512	84.0	180.628	81.033	144.0	181.355	11.709
26.0	177.986	11.485	86.0	180.769	81.043	146.0	181.248	11.727
28.0	177.963	11.457	88.0	180.905	81.054	148.0	181.135	11.743
30.0	177.950	11.430	90.0	181.036	81.067	150.0	181.017	11.757
32.0	177.947	11.402	92.0	181.162	81.082	152.0	180.895	11.770
34.0	177.953	11.374	94.0	181.281	81.099	154.0	180.769	11.781
36.0	177.970	11.346	96.0	181.393	81.117	156.0	180.640	11.791
38.0	177.997	11.319	98.0	181.498	81.137	158.0	180.508	11.798
40.0	178.039	11.292	100.0	181.595	81.158	160.0	180.373	11.804
42.0	178.080	11.266	102.0	181.684	81.180	162.0	180.237	11.808
44.0	178.137	11.240	104.0	181.763	81.204	164.0	180.100	11.811
46.0	178.203	11.215	106.0	181.834	81.228	166.0	179.963	11.811
48.0	178.278	11.191	108.0	181.895	81.254	168.0	179.826	11.810
50.0	178.363	11.168	110.0	181.946	81.280	170.0	179.689	11.806
52.0	178.456	11.146	112.0	181.998	81.306	172.0	179.554	11.801
54.0	178.557	11.126	114.0	182.015	81.334	174.0	179.421	11.794
56.0	178.666	11.107	116.0	182.040	81.361	176.0	179.290	11.786
58.0	178.783	11.090	118.0	182.052	81.389	178.0	179.162	11.775
						180.0	179.038	11.763

## INDEX OF REFRACTION = 4.2

SMALL DELTA	DELTA	PSI	SMALL DELTA	DELTA	PSI	SMALL DELTA	DELTA	PSI
0.0	179.038	11.763	60.0	184.250	13.133	120.0	176.688	13.437
2.0	179.394	11.751	62.0	184.118	13.195	122.0	176.480	13.386
4.0	179.753	11.744	64.0	183.955	13.255	124.0	176.286	13.333
6.0	180.114	11.743	66.0	183.782	13.312	126.0	176.107	13.276
8.0	180.474	11.748	68.0	183.593	13.367	128.0	175.945	13.218
10.0	180.831	11.758	70.0	183.390	13.419	130.0	175.799	13.156
12.0	181.182	11.774	72.0	183.174	13.467	132.0	175.672	13.093
14.0	181.526	11.754	74.0	182.945	13.512	134.0	175.563	13.027
16.0	181.860	11.821	76.0	182.704	13.554	136.0	175.474	12.960
18.0	182.182	11.852	78.0	182.453	13.592	138.0	175.406	12.892
20.0	182.491	11.888	80.0	182.193	13.626	140.0	175.359	12.823
22.0	182.783	11.928	82.0	181.925	13.656	142.0	175.334	12.753
24.0	183.059	11.973	84.0	181.650	13.682	144.0	175.332	12.683
26.0	183.315	12.022	86.0	181.366	13.705	146.0	175.352	12.613
28.0	183.552	12.074	88.0	181.082	13.723	148.0	175.396	12.543
30.0	183.768	12.130	90.0	180.791	13.746	150.0	175.464	12.474
32.0	183.961	12.189	92.0	180.498	13.746	152.0	175.556	12.406
34.0	184.132	12.251	94.0	180.203	13.751	154.0	175.671	12.339
36.0	184.280	12.315	96.0	179.907	13.752	156.0	175.810	12.274
38.0	184.404	12.381	98.0	179.611	13.748	158.0	175.973	12.212
40.0	184.505	12.448	100.0	179.317	13.740	160.0	176.158	12.152
42.0	184.581	12.517	102.0	179.025	13.726	162.0	176.366	12.095
44.0	184.634	12.587	104.0	178.737	13.712	164.0	176.595	12.041
46.0	184.663	12.657	106.0	178.454	13.691	166.0	176.844	11.991
48.0	184.670	12.727	108.0	178.176	13.666	168.0	177.113	11.946
50.0	184.653	12.797	110.0	177.905	13.638	170.0	177.399	11.902
52.0	184.614	12.867	112.0	177.642	13.605	172.0	177.702	11.864
54.0	184.554	12.935	114.0	177.387	13.568	174.0	178.019	11.831
56.0	184.472	13.003	116.0	177.143	13.528	176.0	178.349	11.804
58.0	184.371	13.069	118.0	176.910	13.404	178.0	178.689	11.781
						180.0	179.038	11.763

## INDEX OF REFRACTION = 4.4

SMALL DELTA	DELTA	PSI	SMALL DELTA	DELTA	PSI	SMALL DELTA	DELTA	PSI
0.0	179.038	11.763	60.0	187.690	15.096	120.0	173.183	15.368
2.0	179.850	11.754	62.0	187.318	15.215	122.0	172.798	15.258
4.0	180.663	11.758	64.0	186.962	15.328	124.0	172.437	15.141
6.0	181.470	11.776	66.0	186.562	15.435	126.0	172.101	15.018
8.0	182.264	11.809	68.0	186.142	15.534	128.0	171.794	14.890
10.0	183.038	11.855	70.0	185.703	15.627	130.0	171.517	14.757
12.0	183.785	11.914	72.0	185.247	15.713	132.0	171.272	14.619
14.0	184.500	11.985	74.0	184.776	15.791	134.0	171.062	14.477
16.0	185.177	12.069	76.0	184.290	15.861	136.0	170.888	14.331
18.0	185.811	12.163	78.0	183.793	15.924	138.0	170.754	14.182
20.0	186.400	12.268	80.0	183.285	15.979	140.0	170.660	14.031
22.0	186.939	12.382	82.0	182.768	16.026	142.0	170.610	13.878
24.0	187.426	12.504	84.0	182.243	16.065	144.0	170.605	13.724
26.0	187.860	12.634	86.0	181.713	16.095	146.0	170.648	13.569
28.0	188.239	12.770	88.0	181.178	16.118	148.0	170.741	13.415
30.0	188.564	12.911	90.0	180.639	16.132	150.0	170.885	13.263
32.0	188.834	13.057	92.0	180.095	16.137	152.0	171.081	13.112
34.0	189.050	13.207	94.0	179.559	16.135	154.0	171.331	12.965
36.0	189.212	13.359	96.0	179.020	16.124	156.0	171.635	12.821
38.0	189.323	13.512	98.0	178.484	16.104	158.0	171.994	12.683
40.0	189.384	13.667	100.0	177.952	16.077	160.0	172.408	12.551
42.0	189.397	13.821	102.0	177.425	16.041	162.0	172.876	12.426
44.0	189.364	13.975	104.0	176.905	15.997	164.0	173.396	12.309
46.0	189.286	14.127	106.0	176.393	15.945	166.0	173.966	12.201
48.0	189.166	14.276	108.0	175.892	15.885	168.0	174.584	12.102
50.0	189.007	14.423	110.0	175.402	15.818	170.0	175.246	12.015
52.0	188.810	14.567	112.0	174.925	15.742	172.0	175.947	11.939
54.0	188.577	14.706	114.0	174.463	15.659	174.0	176.683	11.875
56.0	188.312	14.842	116.0	174.017	15.569	176.0	177.448	11.824
58.0	188.015	14.972	118.0	173.590	15.472	178.0	178.235	11.787
						180.0	179.038	11.763

## INDEX OF REFRACTION = 4.6

SMALL DELTA	DELTA	PSI	SMALL DELTA	DELTA	PSI	SMALL DELTA	DELTA	PSI
0.0	179.038	11.763	60.0	190.014	16.534	120.0	170.787	17.179
2.0	180.290	11.757	62.0	189.500	17.096	122.0	170.259	17.022
4.0	181.538	11.774	64.0	188.960	17.249	124.0	169.758	16.856
6.0	182.766	11.816	66.0	188.398	17.392	126.0	169.287	16.681
8.0	183.966	11.880	68.0	187.814	17.524	128.0	168.848	16.497
10.0	185.119	11.967	70.0	187.211	17.647	130.0	168.079	16.106
12.0	186.216	12.076	72.0	186.591	17.760	132.0	167.444	15.900
14.0	187.246	12.204	74.0	185.956	17.861	134.0	167.755	15.688
16.0	188.202	12.350	76.0	185.308	17.953	136.0	167.477	15.469
18.0	189.078	12.513	78.0	184.648	18.033	138.0	167.248	15.246
20.0	189.868	12.691	80.0	183.976	18.103	140.0	167.071	15.019
22.0	190.570	12.882	82.0	183.301	18.161	142.0	166.952	14.875
24.0	191.184	13.084	84.0	182.616	18.209	144.0	166.893	14.789
26.0	191.708	13.296	86.0	181.926	18.245	146.0	166.899	14.557
28.0	192.145	13.514	88.0	181.232	18.271	148.0	166.974	14.324
30.0	192.497	13.739	90.0	180.536	18.285	150.0	167.123	14.092
32.0	192.766	13.968	92.0	179.838	18.288	152.0	167.349	13.862
34.0	192.555	14.199	94.0	179.141	18.280	154.0	167.656	13.634
36.0	193.070	14.432	96.0	178.446	18.260	156.0	168.046	13.412
38.0	193.112	14.665	98.0	177.754	18.230	158.0	168.524	13.197
40.0	193.088	14.896	100.0	177.066	18.188	160.0	169.089	12.989
42.0	193.001	15.125	102.0	176.384	18.135	162.0	169.744	12.792
44.0	192.854	15.350	104.0	175.710	18.072	164.0	170.487	12.607
46.0	192.653	15.571	106.0	175.045	17.997	166.0	171.317	12.436
48.0	192.400	15.787	108.0	174.390	17.912	168.0	172.231	12.280
50.0	192.101	15.997	110.0	173.748	17.816	170.0	173.222	12.142
52.0	191.757	16.200	112.0	173.120	17.709	172.0	174.284	12.023
54.0	191.374	16.395	114.0	172.508	17.592	174.0	175.408	11.924
56.0	190.953	16.583	116.0	171.913	17.464	176.0	176.584	11.848
58.0	190.499	16.763	118.0	171.339	17.327	178.0	177.798	11.794
						180.0	179.038	11.763

## INDEX OF REFRACTION = 4.8

SMALL DELTA	DELTA	PSI	SMALL DELTA	DELTA	PSI	SMALL DELTA	DELTA	PSI
0.0	179.038	11.763	60.0	191.639	18.640	120.0	169.094	18.862
2.0	180.714	11.761	62.0	191.002	18.635	122.0	168.453	18.669
4.0	182.380	11.793	64.0	190.341	19.017	124.0	167.840	18.464
6.0	184.011	11.861	66.0	189.659	19.187	126.0	167.256	18.248
8.0	185.585	11.961	68.0	188.956	19.345	128.0	166.705	18.020
10.0	187.081	12.094	70.0	188.237	19.490	130.0	166.190	17.781
12.0	188.483	12.256	72.0	187.501	19.622	132.0	165.716	17.531
14.0	189.777	12.445	74.0	186.752	19.741	134.0	165.285	17.272
16.0	190.953	12.659	76.0	185.992	19.847	136.0	164.903	17.004
18.0	192.006	12.894	78.0	185.221	19.941	138.0	164.574	16.726
20.0	192.532	13.147	80.0	184.441	20.211	140.0	164.304	16.442
22.0	193.731	13.416	82.0	183.654	20.408	142.0	164.097	16.150
24.0	194.405	13.697	84.0	182.861	20.142	144.0	163.961	15.853
26.0	194.558	13.988	86.0	182.064	20.182	146.0	163.900	15.551
28.0	195.395	14.286	88.0	181.263	20.210	148.0	163.922	15.246
30.0	195.721	14.589	90.0	180.461	20.224	150.0	164.033	14.940
32.0	195.943	14.895	92.0	179.657	20.225	152.0	164.241	14.634
34.0	196.648	15.201	94.0	178.855	20.212	154.0	164.551	14.330
36.0	196.103	15.506	96.0	178.054	20.187	156.0	164.971	14.031
38.0	196.054	15.808	98.0	177.256	20.148	158.0	165.506	13.739
40.0	195.928	16.106	100.0	176.462	20.096	160.0	166.162	13.456
42.0	195.731	16.399	102.0	175.674	20.031	162.0	166.942	13.186
44.0	195.470	16.685	104.0	174.893	19.553	164.0	167.850	12.930
46.0	195.149	16.963	106.0	174.121	19.662	166.0	168.884	12.692
48.0	194.775	17.233	108.0	173.359	19.758	168.0	170.042	12.475
50.0	194.351	17.494	110.0	172.608	19.640	170.0	171.320	12.282
52.0	193.882	17.745	112.0	171.871	19.510	172.0	172.706	12.116
54.0	193.373	17.985	114.0	171.149	19.267	174.0	174.189	11.979
56.0	192.827	18.215	116.0	170.444	19.211	176.0	175.753	11.873
58.0	192.248	18.433	118.0	169.758	19.043	178.0	177.376	11.801
						180.0	179.038	11.763

## INDEX OF REFRACTION = 5.0

SMALL DELTA	DELTA	PSI	SMALL DELTA	DELTA	PSI	SMALL DELTA	DELTA	PSI
0.0	175.038	11.763	60.0	192.803	20.216	120.0	167.869	20.419
2.0	181.126	11.765	62.0	192.072	20.436	122.0	167.141	20.198
4.0	183.193	11.815	64.0	191.320	20.641	124.0	166.437	19.963
6.0	185.204	11.910	66.0	190.548	20.832	126.0	165.762	19.714
8.0	187.125	12.051	68.0	189.750	21.028	128.0	165.110	19.450
10.0	188.930	12.233	70.0	188.953	21.170	130.0	166.509	19.173
12.0	190.594	12.452	72.0	188.114	21.316	132.0	163.939	18.883
14.0	192.104	12.706	74.0	187.304	21.458	134.0	163.413	18.580
16.0	193.449	12.989	76.0	186.463	21.566	136.0	162.935	18.265
18.0	194.626	13.297	78.0	185.614	21.668	138.0	162.512	17.938
20.0	195.634	13.626	80.0	184.757	21.756	140.0	162.140	17.601
22.0	196.478	13.971	82.0	183.894	21.829	142.0	161.852	17.293
24.0	197.164	14.329	84.0	183.026	21.887	144.0	161.629	16.897
26.0	197.702	14.696	86.0	182.154	21.930	146.0	161.489	16.533
28.0	198.100	15.069	88.0	181.279	21.959	148.0	161.439	16.164
30.0	198.369	15.444	90.0	180.403	21.973	150.0	161.489	15.790
32.0	198.520	15.820	92.0	179.527	21.973	152.0	161.648	15.415
34.0	198.561	16.193	94.0	178.651	21.957	154.0	161.927	15.039
36.0	198.504	16.562	96.0	177.777	21.927	156.0	162.336	14.667
38.0	198.356	16.925	98.0	176.905	21.883	158.0	162.885	14.301
40.0	198.128	17.281	100.0	176.038	21.823	160.0	163.584	13.944
42.0	197.826	17.628	102.0	175.175	21.749	162.0	164.440	13.599
44.0	197.457	17.964	104.0	174.318	21.660	164.0	165.461	13.272
46.0	197.029	18.290	106.0	173.470	21.557	166.0	166.651	12.966
48.0	196.547	18.605	108.0	172.630	21.438	168.0	168.009	12.685
50.0	196.017	18.907	110.0	171.800	21.305	170.0	169.531	12.434
52.0	195.444	19.196	112.0	170.983	21.157	172.0	171.208	12.217
54.0	194.832	19.472	114.0	170.179	20.995	174.0	173.022	12.038
56.0	194.186	19.734	116.0	169.391	20.818	176.0	174.952	11.901
58.0	193.508	19.982	118.0	168.620	20.626	178.0	176.968	11.809
						180.0	179.038	11.763

## INDEX OF REFRACTION = 20.0

SMALL DELTA	DELTA	PSI	SMALL DELTA	DELTA	PSI	SMALL DELTA	DELTA	PSI
0.0	175.038	11.763	60.0	188.056	42.980	120.0	171.993	42.986
2.0	200.526	13.110	62.0	187.440	43.550	122.0	171.356	42.907
4.0	212.753	16.385	64.0	186.841	43.113	124.0	170.697	42.819
6.0	217.621	20.124	66.0	186.256	43.169	126.0	170.012	42.721
8.0	218.781	23.623	68.0	185.690	43.219	128.0	169.300	42.610
10.0	218.206	26.671	70.0	185.135	43.262	130.0	168.557	42.487
12.0	216.824	29.251	72.0	184.592	43.301	132.0	167.780	42.347
14.0	215.082	31.449	74.0	184.056	43.334	134.0	166.966	42.190
16.0	213.205	33.206	76.0	183.534	43.363	136.0	166.110	42.013
18.0	211.311	34.703	78.0	183.019	43.388	138.0	165.208	41.812
20.0	209.463	35.952	80.0	182.516	43.408	140.0	164.256	41.584
22.0	207.693	36.998	82.0	182.005	43.429	142.0	163.247	41.324
24.0	206.017	37.878	84.0	181.505	43.437	144.0	162.177	41.026
26.0	204.439	38.622	86.0	181.098	43.446	146.0	161.040	40.685
28.0	202.559	39.254	88.0	180.514	43.452	148.0	159.828	40.290
30.0	201.572	39.793	90.0	180.020	43.454	150.0	159.536	39.833
32.0	200.273	40.256	92.0	179.526	43.452	152.0	157.156	39.300
34.0	199.555	40.655	94.0	179.031	43.447	154.0	155.684	38.676
36.0	197.912	41.001	96.0	178.535	43.438	156.0	154.114	37.943
38.0	196.836	41.301	98.0	178.035	43.426	158.0	152.445	37.075
40.0	195.823	41.564	100.0	177.531	43.410	160.0	150.683	36.043
42.0	194.867	41.795	102.0	177.022	43.390	162.0	149.841	34.812
44.0	193.961	41.958	104.0	176.506	43.365	164.0	146.949	33.337
46.0	193.101	42.177	106.0	175.983	43.337	166.0	145.067	31.566
48.0	192.284	42.335	108.0	175.451	43.304	168.0	143.307	29.439
50.0	191.504	42.476	110.0	174.905	43.266	170.0	141.885	26.896
52.0	190.759	42.601	112.0	174.355	43.222	172.0	141.220	23.886
54.0	190.044	42.712	114.0	173.780	43.173	174.0	142.186	20.420
56.0	189.358	42.812	116.0	173.207	43.118	176.0	146.642	16.684
58.0	188.696	42.900	118.0	172.609	43.055	178.0	158.116	13.327
						180.0	179.038	11.763

## INDEX OF REFRACTION = 50.0

SMALL DELTA	DELTA	PSI	SMALL DELTA	DELTA	PSI	SMALL DELTA	DELTA	PSI
0.0	175.038	11.763	60.0	183.386	44.670	120.0	176.622	44.671
2.0	216.730	18.531	62.0	183.120	44.683	122.0	176.345	44.657
4.0	219.142	27.120	64.0	182.863	44.594	124.0	176.057	44.661
6.0	215.293	32.864	66.0	182.615	44.703	126.0	175.755	44.624
8.0	210.896	36.479	68.0	182.374	44.712	128.0	175.438	44.604
10.0	206.986	38.793	70.0	182.139	44.719	130.0	175.105	44.581
12.0	203.705	40.320	72.0	181.911	44.726	132.0	174.751	44.555
14.0	200.587	41.363	74.0	181.687	44.732	134.0	174.376	44.526
16.0	198.731	42.099	76.0	181.467	44.737	136.0	173.977	44.492
18.0	196.842	42.633	78.0	181.251	44.741	138.0	173.548	44.454
20.0	195.244	43.033	80.0	181.035	44.744	140.0	173.087	44.410
22.0	193.877	43.337	82.0	180.825	44.747	142.0	172.589	44.358
24.0	192.695	43.574	84.0	180.621	44.749	144.0	172.047	44.298
26.0	191.662	43.763	86.0	180.414	44.751	146.0	171.454	44.226
28.0	190.753	43.914	88.0	180.208	44.752	148.0	170.802	44.142
30.0	189.944	44.037	90.0	180.003	44.752	150.0	170.080	44.041
32.0	189.219	44.139	92.0	179.798	44.752	152.0	169.274	43.918
34.0	188.565	44.224	94.0	179.592	44.751	154.0	168.368	43.768
36.0	187.971	44.296	96.0	179.386	44.749	156.0	167.340	43.581
38.0	187.477	44.356	98.0	179.178	44.747	158.0	166.163	43.345
40.0	186.920	44.408	100.0	178.968	44.744	160.0	165.802	43.043
42.0	186.466	44.453	102.0	178.755	44.741	162.0	163.212	42.648
44.0	186.036	44.491	104.0	178.540	44.737	164.0	161.333	42.118
46.0	185.636	44.525	106.0	178.320	44.732	166.0	159.090	41.389
48.0	185.260	44.554	108.0	178.097	44.726	168.0	156.388	40.358
50.0	184.906	44.580	110.0	177.866	44.720	170.0	153.125	38.850
52.0	184.572	44.603	112.0	177.634	44.712	172.0	149.234	36.567
54.0	184.254	44.623	114.0	177.393	44.704	174.0	144.846	33.003
56.0	183.952	44.641	116.0	177.144	44.694	176.0	140.941	27.350
58.0	183.663	44.656	118.0	176.888	44.683	178.0	142.921	18.833
						180.0	179.039	11.763